Comparing Dialysis Modality and Cardiovascular Mortality in Patients on Hemodialysis and Peritoneal Dialysis

Hany Refaat, Dawlat Sany, Amr Mohab, Haitham Ezzat

Patients undergoing dialysis are at high risk for cardiovascular disease (CVD). Mortality differences between peritoneal dialysis (PD) and hemodialysis (HD) are widely debated. The question of whether dialysis modality affects the risk for CVD remains to be addressed.

In the present study, we evaluated the influence of hemodialysis (HD) and peritoneal dialysis (PD) on survival and the risk of developing de novo *CVD. Our observational prospective study enrolled 157 end-stage renal disease patients on HD or PD for 12 months. Patients with a history of malignancy, chronic rheumatic heart disease, congenital heart disease, previous cardiac surgery, or previous transplantation, and patients started on dialysis less than 3 months earlier were excluded from the study. Detailed medical history, demographic data, and routine laboratory investigations were obtained, and patients were follow every 3 months for 12 months. Cardiac echography was performed at baseline and at 6 months. Nutrition status was scored using the standardized 7-point subjective global assessment (SGA). Baseline comorbidities included the presence or absence of coronary artery disease (angina, myocardial infarction, and coronary artery bypass surgery), peripheral vascular disease, hypertension, diabetes mellitus, and cerebrovascular disease.*

Of the 157 patients, 121 were on HD (60 men, 61 women; mean age: 59.3 years), and 36 were on PD (14 men, 22 women; mean age: 50.8 years, $p = 0.13$*). The dialysis duration was significantly different in the two groups (HD: 52.96 ± 38.3; PD: 30.89 ± 26.3;* $p = 0.02$*). Of the HD patients, 95.04% were hypertensive, and 61.98% were diabetic; of the PD patients, 91.66% were hypertensive, and 50% were diabetic. Body mass index and SGA score were not significantly different between the two groups. Patients on PD had a higher residual urine volume (383.66 ± 548.393 mL vs. 12.40 ± 96.238 mL in the HD patients,* $p < 0.001$*).*

In comparing traditional cardiovascular risk factors at the start of the study, PD patients had higher levels of total cholesterol (4.5 ± 1.33 mmol/L vs. 3.85 ± 1.34 mmol/L in HD patients, $p < 0.05$*), low-density lipoprotein cholesterol (2.84 ± 1.31 mmol/L vs. 2.06 ± 0.89 mmol/L,* $p < 0.001$*), high-density lipoprotein cholesterol (1.10 ± 0.26 mmol/L vs. 0.91 ± 0.32 mmol/L,* $p < 0.005$*). Cardiovascular morbidity affected 17 HD patients and 2 PD patients. A Cox proportional hazards model for cardiovascular events showed a trend suggesting that PD was safer, but the data did not reach statistical significance. Kaplan–Meir survival analysis revealed 12 death events in HD patients compared with 4 events in PD patients—a difference that was not statistically significant.*

Cardiovascular morbidity during chronic dialysis was prevalent among the older patients (>57 years) and those who used more than 1 antihypertensive medication; an ejection fraction exceeding 53% was found to be cardioprotective. For all-cause mortality, dialysis modality was a nonsignificant risk factor; age and Kt/V were significant.

Key words
Cardiovascular morbidity, dialysis modality, risk factors

Introduction

Cardiovascular disease (CVD) is the leading cause of death in patients undergoing maintenance dialysis.

From: Nephrology Department, Ain Shams University, Cairo, Egypt.

Compared with the general population, dialysis patients have an incidence of cardiovascular death that is 10 – 20 times greater (1–4). The increased incidence of CVD in dialysis patients is only partly explained by an increased prevalence of traditional risk factors such as hypertension, diabetes mellitus, dyslipidemia, smoking, obesity, and physical inactivity (5,6). Additional risk might be conferred by nontraditional factors that are frequently observed in advanced chronic kidney disease, such as hyperhomocysteinemia, anemia, abnormal calcium and phosphate metabolism, inflammation, malnutrition, oxidative stress, and elevated lipoprotein (5,7–10).

Limited evidence has suggested that dialysis modality might also influence CVD risk. Bleyer *et al.* (11) observed an increased risk of cardiac death in hemodialysis (HD) patients immediately after weekends, possibly related to the more frequent occurrence of hyperkalemia and fluid overload at that time. In contrast, the continuous nature of peritoneal dialysis (PD) could potentially minimize cardiovascular risk related to fluctuations in body fluid and electrolyte composition. Patients on HD can also be exposed to a greater risk of CVD because of more rapid loss of residual renal function (12,13) and more hyperdynamic circulation conferred by the presence of an arteriovenous fistula and extracorporeal circulation (14). On the other hand, PD patients are exposed to greater amounts of glucose in dialysate, leading to a much higher prevalence of insulin resistance, dyslipidemia, and metabolic syndrome (15). There is also evidence that PD patients show greater coagulability, possibly related to dyslipidemia (16).

However, because dialysis outcomes consequent to the use of the chosen dialysis modality can be affected by various factors, interpretation is not always straightforward. In that regard, several reports have indicated that the characteristics and outcomes of dialysis patients can vary according to their racial or ethnic group. An analysis of the U.S. Renal Data System in 1998 revealed that, compared with their white counterparts, patients of Asian ethnicity were younger at initiation of dialysis therapy and had a lower body mass index (17). The primary causes of ESRD in patients of Asian and white ethnicity also differed: the Asian patients had more glomerulonephritis and diabetes, but less cystic kidney disease and hypertension (17). In addition, baseline coronary artery disease, congestive heart failure, hypertension, and peripheral vascular disease were significantly less prevalent in Asian than in white patients (18). Furthermore, overall and cardiovascular mortality in dialysis patients can show significant differences according to racial or ethnic group (19–22). A determination of whether the results from previous studies, conducted almost exclusively in Western populations, can be appropriately generalized to other racial or ethnic groups therefore seems necessary; however, only a few studies to date have compared outcomes between HD and PD in Asian patients (23,24). Hence, we here present the results of a cohort study comparing cardiovascular and all-cause mortality in HD and PD patients, and evaluating the relationship between mortality and various baseline covariates.

Methods

Study design

This prospective single-center observational study enrolled stable ESRD patients receiving renal replacement using HD or PD. The study duration was 12 months.

Study population

Adult patients (18 years of age and older) receiving renal replacement therapy at King Fahd Armed Forces Hospital who were able to give consent or whose appropriate guardian could give consent were eligible if they been on renal replacement therapy for at least 3 months. Patients with history of malignancy, chronic rheumatic heart disease, congenital heart disease, previous cardiac surgery, or previous transplantation were excluded. The study was performed according to the Declaration of Helsinki and was approved by the institutional ethics committee.

PATIENT CLASSIFICATION

The patients were considered to have CVD if they had ischemic heart disease, defined as any of these conditions:

- Coronary artery disease documented by coronary angiography or, in the absence of coronary angiography, by any of the following clinico-instrumental findings of coronary insufficiency: angina pectoris associated with ischemic electrocardiographic (ECG) changes, ischemic ECG changes during a stress test, or ischemic scintigraphic changes during a stress test.

- Myocardial infarction documented by ECG changes or a pathologic increase in myocardial necrosis markers after an episode of angina pectoris or heart failure (acute myocardial infarction), or both; or documented by any of these signs of prior myocardial infarction: Q-waves at ECG, akinetic areas at echocardiography, or necrotic areas at myocardial scintigraphy.
- Congestive heart failure or overhydration, or both, documented by any sign of a failure to pump at a rate commensurate with the requirements of metabolizing tissues. That definition included any of these conditions: more than 1 episode of pulmonary edema while the patient was at normal dry body weight in the judgment of the attending nephrologist, an echocardiographic finding of systolic dysfunction, or a finding of cardiomegaly regardless of the imaging technique (chest radiography or echocardiography).

A total of 192 ESRD patients on both maintenance HD ($n = 150$) and PD ($n = 42$) were screened. After application of the exclusion criteria, 157 patients were eligible (121 on HD, 36 on PD). The 29 excluded HD patients were disqualified either because of past history (1 each with malignancy, congenital heart disease, rheumatic heart disease, prior cardiac surgery), dialysis initiation less than 3 months earlier ($n = 11$), or a prior history of renal transplantation ($n = 14$). The 6 patients excluded from PD group were disqualified either because of prior cardiac surgery (n = 2), prior transplantation (n = 2), or dialysis start less than 3 months earlier (n = 2).

Demographic data included age, sex, height, weight (as body mass index), comorbidities, laboratory data, and dialysis information. Baseline comorbidities included the presence or absence of coronary artery disease (angina, myocardial infarction, and coronary artery bypass surgery), peripheral vascular disease, hypertension, diabetes mellitus, and cerebrovascular disease. All were categorized as "yes" or "no." Nutrition status was scored using the standardized 7-point subjective global assessment, which is based on the clinical judgment of the dietitian. Baseline laboratory parameters were used in the adjusted analyses, and patients were followed every 3 months for 12 months. Echocardiography was performed at baseline and after 6 months.

Statistical analysis

Patient characteristics were compared using the Pearson chi-square test or the Fisher exact test for categorical variables and the Student t-test for continuous variables. The univariate descriptive survival analyses were based on the Kaplan–Meier technique, with events being defined as death from any cause or the development of *de novo* CVD (with or without death). The patients were classified as belonging to the HD or PD group based on the treatment they were receiving 1 month after the start of renal replacement therapy, and patient survival was tracked based on that treatment modality. Patients were censored for all-cause mortality. Cox proportional hazards regression models were used to compare survival (endpoint: death) and the risk of developing *de novo* CVD events in the two groups. The models were adjusted for the effect of age and sex. All statistical analyses were performed using the SPSS software application (version 10.0: SPSS, Chicago, IL, U.S.A.) with $p \leq 0.05$ considered significant.

Results

Patient characteristics and follow-up

Table I shows the characteristics of the final study population.

In the overall cohort, average age was 57.17 years, 48% ($n = 75$) were men, 59.2% ($n = 93$) had diabetes, and 94.3% ($n = 148$) were hypertensive. Baseline clinical parameters including sex, body mass index, comorbidities, subjective global assessment, and Kt/V were not significantly different between the PD and the HD patients. Patients on HD had a longer dialysis duration (53 ± 38 months vs. 31 ± 26 months in PD patients, $p < 0.005$) and were older (59.3 ± 17.1 years vs. 50.8 ± 19.4 years, $p < 0.05$). Patients on PD had higher residual urine volume (383.66 ± 548.393 mL vs. 12.40 ± 96.238 mL in HD patients, $p < 0.001$) and a higher Kt/V (1.87 ± 0.68 vs. 1.47 ± 0.27, $p < 0.001$).

Univariate analysis at the start of the study showed (Table II) that PD patients had higher hemoglobin (11.3±1.4 g/dL vs. 10.8 ± 1.4 g/dL in HD patients, $p < 0.05$) and lower serum albumin (35.3 ± 3.9 g/L vs. 40.3 ± 5.7 g/L, $p < 0.001$). Both groups had low vitamin D2 levels, with the PD patients having significantly lower levels (25.15 ± 22.19 nmol/L vs. 51.7 ± 31.7 nmol/L in HD patients, $p < 0.001$). Comparing traditional cardiovascular risk factors at the start of the study, PD patients had higher levels of total cholesterol

TABLE I Baseline characteristics of the study patients

Variable	*Modality group*		p *Value*
	HD	*PD*	
Patients (*n*)	121	36	
Mean age (years)	59.31±17.09	50.86±19.4	0.013
Sex [*n* (%)]			
Women	60 (49.58)	22 (61.1)	0.307
Men	61 (50.41)	14 (38.88)	
Smoking [*n* (%)]	28 (23.14)	7 (19.44)	0.81
Mean dialysis duration (months)	52.96±38.3	30.89±26.3	0.02
Hypertension [*n* (%)]			
Patients	115 (95.04)	33 (91.66)	0.722
Patients taking medication	55 (45.45)	29 (80.55)	0.000
Diabetes mellitus [*n* (%)]			
Patients	75 (61.98)	18 (50)	0.253
Patients taking medication	54 (44.62)	16 (44.44)	0.923
Atrial fibrillation [*n* (%)]	10 (8.26)	2 (5.55)	NS
Ischemic heart disease [*n* (%)]	24 (19.83)	5 (13.88)	NS
Cardiomyopathy [*n* (%)]	13 (10.74)	3 (8.33)	NS
Collagen diseases [*n* (%)]	3 (2.470)	1 (2.77)	NS
Chronic liver disease [*n* (%)]	29 (23.96)	4 (11.11)	NS
Cerebrovascular accident [*n* (%)]	33 (27.27)	4 (11.11)	NS
Peripheral vascular disease [*n* (%)]	12 (9.91)	4 (11.11)	NS
Endocarditis [*n* (%)]	1 (0.82)	1 (2.77)	NS
Mean residual urine (mL)	12.40±96.2	383.66±548.3	<0.001
Mean body mass index	27.55±6.46	26.70±7.1	0.503
Moderate-to-severe malnutrition [*n* (%)][a]	26 (21.48)	9 (25)	NS
Edema [*n* (%)]	4 (3.3)	9 (25)	<0.005
Mean Kt/V [*n* (%)]	1.47±0.27	1.87±0.68	<0.001

[a] By subjective global assessment.
HD = hemodialysis; PD = peritoneal dialysis; NS = nonsignificant.

(4.5 ± 1.33 mmol/L vs. 3.85 ± 1.34 mmol/L for HD patients, $p < 0.05$), low-density lipoprotein cholesterol (2.84 ± 1.31 mmol/L vs. 2.06 ± 0.89 mmol/L, $p < 0.001$), and high-density lipoprotein cholesterol (1.10 ± 0.26 mmol/L vs. 0.91 ± 0.32 mmol/L, $p < 0.005$) and a lower ejection fraction (49.4% ± 13.2% vs. 54.0% ± 10.5%, $p < 0.05$). No significant differences were observed with respect to left ventricular mass index (113.3 ± 36.2 g/m^2 in PD patients vs. 100.4 ± 34.37 g/m^2 in HD patients, $p = 0.07$), valve calcification ratio [8/36 (22.2%) in PD patients vs. 28/121 (23.1%) in HD patients, $p = 0.93$].

Repeated-measures 2-way analysis of variance was used to compare biochemical variables (Table III) over time, showing that, compared with HD patients, PD patients had higher serum hemoglobin, iron, and calcium ($p < 0.05$). We observed no significant differences between the PD and HD patients with respect to change of left ventricular mass index from the start of the study to 6 months after (PD: 113.3 ± 36.27 g/m^2 vs. 106 ± 35.2 g/m^2, $p > 0.05$; HD: 100.4 ± 34.37 g/m^2 vs. 97 ± 29 g/m^2, $p > 0.05$) nor in ejection fraction (PD: 49.4% ± 13.2% vs. 50.00% ± 11.42%, $p > 0.05$; HD: 54.0% ± 10.5% vs. 54.02 ± 11.38, $p > 0.05$).

TABLE II Basal biochemical values[a] in the study cohort

Variable	*Modality group*		p *Value*
	HD	*PD*	
Hemoglobin (g/dL)	10.8±1.4	11.3±1.4	0.05
Iron (μmol/L)	10.2±4.4	11.3±4.9	0.202
Ferritin (μg/L)	391.9±490.9	492.1±334.2	0.253
Transferrin saturation (%)	24.65±12.9	25.1±1.05	0.848
Calcium (mmol/L)	2.23±0.23	2.15±0.19	0.07
Albumin (g/L)	40.3±5.7	35.3±3.92	<0.001
Phosphate (mmol/L)	1.59±068	1.71±0.56	0.388
PTH (pmol/L)	38.97±37.8	46.92±83.09	0.418
C-Reactive protein (mg/L)	26.36±55.36	17.79±34.16	0.381
HbA1C (%)	6.65±1.19	6.63±1.62	0.43
Vitamin D2 (nmol/L)	51.7±31.7	25.15±22.19	<0.001
Insulin (pmol/L)	181±257.9	102.9±106.3	0.167
Total cholesterol (mmol/L)	3.85±1.34	4.5±1.33	<0.05
LDL cholesterol (mmol/L)	2.06±0.89	2.84±1.31	<0.001
HDL cholesterol (mmol/L)	0.919±0.32	1.10±0.26	<0.005
Homocysteine (μmol/L)	54.46±32.95	40.53±22.63	0.062

[a] Mean ± standard deviation.
HD = hemodialysis; PD = peritoneal dialysis; PTH = parathyroid hormone; LDL = low-density lipoprotein; HDL = high-density lipoprotein.

For the 12-month follow-up period, Kaplan–Meir survival curves comparing cardiovascular events between the HD and PD groups showed no statistically significant difference ($p > 0.05$, Figure 1). The HD group experienced 17 cardiovascular events (4 instances of new cerebrovascular accident, 7 instances of new-onset atrial fibrillation, 2 instances of congestive heart failure, 2 myocardial infarctions, 1 cardiac arrest, and 1 cardiac surgery) compared with 2 events in the PD group (1 cardiac surgery and 1 myocardial infarction). To further examine the relationship between dialysis modality and cardiovascular events, each potential risk factor was entered into a Cox proportional hazards model, which showed a trend toward PD being safer, but which did not reach statistical significance [hazard ratio (HR): 1.19; 95% confidence interval (CI): 0.03 to 1.171; $p = 0.07$]. Older age (>57 years) was an independent factor positively associated with mortality (HR: 1.05; 95% CI: 1.013 to 1.088; $p < 0.05$); use of many antihypertensive medications (HR: 1.75; 95% CI: 1.018 to 2.794; $p < 0.05$) was associated with higher risk; and ejection fraction greater than 53% was found to be cardioprotective (HR: 0.96; 95% CI: 0.925 to 1.00; $p < 0.05$).

For the second endpoint of death, Kaplan–Meir survival analysis of the 12 events in the HD group compared with the 4 events in the PD group demonstrated that the difference was not statistically significant (Figure 2). Cox proportional hazards modeling for all-cause mortality showed that older age (>57 years) was associated with higher risk (HR: 1.04; 95% CI: 1.002 to 1.081; $p < 0.05$), and ejection fraction greater than 53% conferred a survival benefit (HR: 0.96; 95% CI: 0.912 to 0.984; $p < 0.05$).

In Kaplan–Meir survival analysis, the combined endpoint of cardiovascular events and death did not show a statistically significant difference (Figure 3). Cox proportional hazards modeling showed that older age and Kt/V were both significant variables, with older age (>57 years) being associated with higher risk (HR: 1.05; 95% CI: 1.02 to 1.08; $p < 0.05$) and higher Kt/V conferring a survival benefit (HR: 0.36; 95% CI: 0.120 to 0.96; $p < 0.05$).

TABLE III Biochemical values[a] in the cohort throughout the study period

Variable	*Modality*	*Study month* 0	3	6	9	12	p *Value*
Hemoglobin (g/dL)							
	HD	10.8±1.4	10.8±1.14	11.0±1.18	10.8±1.3	10.8±1.2	<0.05 within and between the groups
	PD	11.3±1.4	11.1±1.6	10.6±1.8	10.6±1.8	10.1±1.6	
Iron (μmol/L)							
	HD	10.2±4.5	9.3±4.24	10.8±5.5	10.9±6.2	10.56±5.07	<0.05 between the groups
	PD	11.1±4.67	11.3±4.47	11.5± 3.9	9.8± 3.57	9.370 ±3.23	
Ferritin (μg/L)							
	HD	401± 518	337± 418	339± 403	364± 353	418.±498.44	NS
	PD	466 ± 296	443± 217	468± 237	509± 333	545 ±290	
Transferrin saturation (%)							
	HD	25.1±13.5	22.4±13.3	25.2±13.6	25.1±14.9	24.6±12.9	NS
	PD	23.3±8.8	22.5±7.1	25.1±8.3	23.3±8.7	21.0±6.8	
Total cholesterol (mmol/L)							
	HD	3.86±1.34	3.83±1.69	3.79±1.44	4.14±3.6	3.6±2.9	<0.05
	PD	4.74±1.24	4.83±1.5	4.6±1.4	4.5±1.6	4.1±1.1	
LDL cholesterol (mmol/L)							
	HD	2.10±0.92	1.96±0.79	2.10±0.87	2.03±0.91	1.80±0.7904	<0.05 within the HD group; not within the PD group
	PD	3.04±1.4	2.78±1.0	2.77±1.1	2.68±1.22	2.39±0.96	
HDL cholesterol (mmol/L)							
	HD	0.92±0.32	0.93±0.34	0.96±0.41	2.06±0.41	1.49±0.48	NS
	PD	1.13±0.28	1.15±0.33	1.11±0.29	1.17±0.43	1.12±0.35	
Calcium (mmol/L)							
	HD	2.24±0.18	2.15±0.17	2.21±0.15	2.19±0.15	2.24±0.19	<0.05 between the groups
	PD	2.14±0.20	2.18±0.22	2.11±0.21	2.11±0.23	2.16±0.18	
Phosphate (mmol/L)							
	HD	1.57±0.69	1.40±0.51	1.47±0.57	1.48±0.56	1.62±0.68	<0.05 within the same group
	PD	1.70±0.61	1.59±0.49	1.71±0.51	1.59±0.45	1.73±0.56	
Albumin (g/L)							
	HD	40.51±6.05	40.17±6.20	40.20±6.11	39.60±7.01	39.96±6.05	NS
	PD	35.88±3.81	35.85±4.21	35.51±3.99	34.07±5.82	34.67±5.05	
PTH (pmol/L)							
	HD	38.05±37.49	33.81±31.82	36.86±33.55	40.87±38.25	38.75±36.59	NS
	PD	49.44±94.8	52.06±69.23	47.9±46.07	57.02±48.12	51.82±49.44	
C-Reactive protein (mg/L)							
	HD	28.65±58.96	15.20±38.70	19.21±34.25	25.31±44.33	15.41±29.16	NS
	PD	21.16±38.75	17.80±19.77	19.22±30.71	18.59±22.87	33.93±63.80	
HbA1C (%)							
	HD	7.22±2.25	7.09±2.45	7.15±1.66	6.84±1.66	7.59±5.72	NS
	PD	7.38±1.23	7.66±1.58	7.88±1.89	8.02±1.69	8.20±1.96	

[a] Mean ± standard deviation.

HD = hemodialysis; PD = peritoneal dialysis; NS = nonsignificant; LDL = low-density lipoprotein; PTH = parathyroid hormone.

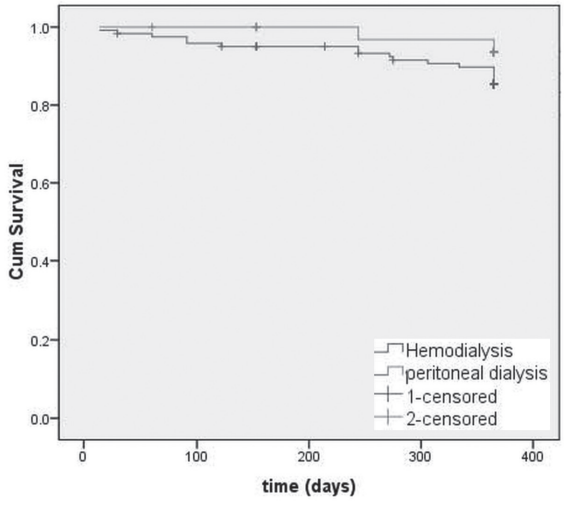

FIGURE 1 Kaplan–Meier plot of the cardiovascular survival curve in relation to dialysis modality.

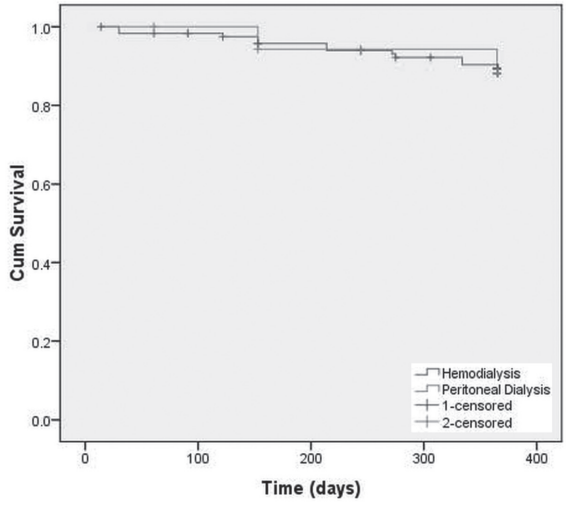

FIGURE 2 Kaplan–Meier plot of all-cause mortality in relation to dialysis modality.

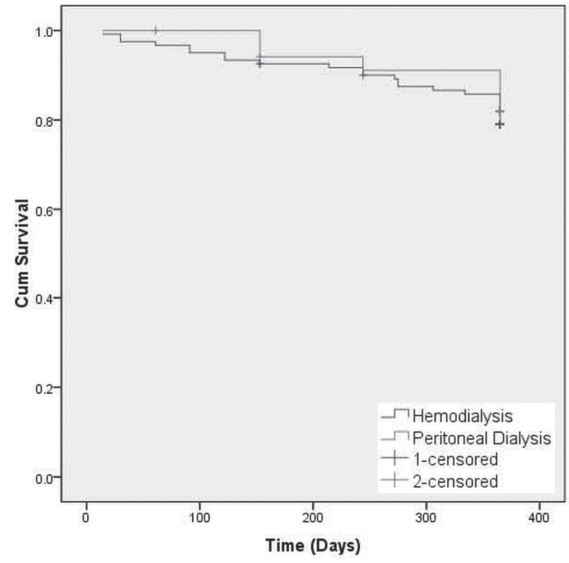

FIGURE 3 Kaplan–Meier plot of combined mortality in relation to dialysis modality.

Discussion

In the present study, we compared clinical outcomes in dialysis patients using different dialysis modalities. The influence of dialysis modality on patient survival is still somewhat controversial. Randomized controlled trials are ideal for obtaining such information, but a previous trial that compared clinical outcomes based on dialysis modality failed (25) because of the difficulty of randomizing against patient preference. Alternatively, to overcome those limitations, prospective cohort studies and skillful analyses with causal models have been attempted since the 2000s (26,27). However, only one prospective observational study in the Asian ESRD population has been performed: 83 PD and 83 HD patients were recruited in a region of Japan. That study reported similar mortality for the two dialysis modalities in Japanese prevalent ESRD patients (28). It also showed that, compared with HD patients, PD patients were younger, had a shorter dialysis duration, and had a lower proportion of hypertensive medication use. Moreover, PD patients had higher serum hemoglobin, better-preserved 24-hour urine volume, and a higher Kt/V both at dialysis commencement and throughout the follow-up period.

The better baseline characteristics observed in the PD patients accord with data from other countries such as the United States and Canada (26,29,30). After balancing all of the measured baseline characteristics between the two dialysis modalities, the present study showed a trend toward better cardiovascular outcomes with PD in the early period of dialysis; however, the adjusted risk for all-cause mortality did not differ between PD and HD during the first year. The PD

patients in our study were not exposed to a high level of glucose or glucose degradation products because icodextrin dialysate was available.

The superior outcomes with PD in the early period of dialysis accord with data reported from several previous studies in various cohorts. A comparison of clinical outcomes found a survival advantage for PD relative to HD during the first 2 years of dialysis therapy in U.S. Medicare patients (31), in a Canadian dialysis population (32), in Danish registry data (33), and in the U.S. DaVita database (34). On the other hand, the CHOICE study group reported that the adjusted risk of death did not differ between the two dialysis modalities during the first year, but was significantly higher in PD patients in the second year (26). The Netherlands Cooperative Study on the Adequacy of Dialysis study group also reported a similar mortality rate in the first 2 years of dialysis and better outcomes later for HD compared with PD (35).

A supplementary analysis of data from the first 90 days revealed that 26% of deaths occurring in the first year of dialysis occurred within the first 90 days, which is similar to the 32% reported by Soucie *et al.* (36). In addition, the two dialysis modalities showed similar mortalities within the first 90 days. Subgroup analyses of the first 90 days in several cohorts generated conflicting results. In an elderly ESRD cohort from the United States, it was found that, compared with the HD patients, the PD patients had a 16% higher rate of death during the first 90 days of renal replacement therapy (37). However, the ANZDATA registry reported lower mortality for PD compared with HD in the first 90 days; the reason was likely catheter use in HD patients beginning renal replacement therapy (27). Patients who start dialysis urgently are treated almost exclusively with HD and frequently use tunneled or non-tunneled catheters. The use of a catheter in HD is associated with a higher mortality rate (38,39). However, no difference in survival between PD and HD was previously reported in an analysis of patients who started dialysis electively (30). Kim *et al.* (40) showed that the overall mortality rate was higher in PD patients than in HD patients. In a study using U.S. Renal Data System data, no significant difference in the mortality risk between HD and PD patients was observed in the 2002–2004 cohorts (41). Another study analyzing a Centers for Medicare and Medicaid Services cohort, which consisted of adult patients who initiated dialysis in the United States in 2003, showed that overall survival was similar for HD and PD patients who survived for the first 90 days (26). Furthermore, the most recent large-scale European study showed that the overall adjusted survival benefit was significantly higher in PD patients than in HD patients (42). However, it should be noted that, although the relative survival rate in PD patients seems to be less than that in HD patients, the survival rate for the PD patients in the present study was not low in absolute terms when compared with rates in previous studies (27,41,43,44).

In the present study, we explored the effects of interactions between dialysis modality and various baseline covariates for mortality, finding that age was the most important determinant of dialysis modality–related mortality. Among patients more than 57 years of age, other baseline covariates had a marginal effect on mortality. Notably, for those other covariates, we observed no significant mortality interactions of diabetes, myocardial infarction, or congestive heart failure with dialysis modality ($p > 0.05$), which contrasts with the results of previous studies (31,43,45,46). Furthermore, in contrast to the results of a recent European study by van de Luijtgaarden *et al.* (42), we observed no interaction between sex and dialysis modality ($p = 0.645$). The same study also showed that the absence of diabetes, ischemic heart disease, peripheral vascular disease, cerebrovascular disease, and malignancy was associated with better survival in PD patients than in HD patients. In contrast, our models showed that the presence or absence of such comorbidities had no effect on mortality.

Finally, another interesting finding of our study was that the trend for lower cardiovascular mortality events in PD patients compared with HD patients was relatively constant over a 12-month duration of dialysis therapy. That result accords with findings in other earlier studies, in which survival was better in PD patients in the early years (usually in the first 12 – 24 months after initiation of dialysis therapy); thereafter, outcomes in the various study participants varied (27,29,31,33,43). The reason for the difference is not clear, but it can be speculated that some previously established factors related to the early benefits of PD—such as better preservation of residual renal function in PD, or lower incidences of late referral–related and vascular access–related complications in HD patients—provided relatively smaller benefits to the participants in our study (12,29,39).

Our study has several potential limitations. The dialysis modalities were not randomly assigned, and the study subjects were followed for a relatively short period. In addition, we could not avoid selection bias, which means that some very ill and very healthy dialysis patients were not included. Nevertheless, this prospective Asian cohort study presents a comparison of mortality outcomes based on dialysis modality.

Conclusions

Compared with HD patients, PD patients were younger, were taking fewer antihypertensive medications, and had higher serum hemoglobin and better Kt/V. Compared with a HD population, our PD population showed a trend toward better cardiovascular outcomes in the early period of dialysis. Further analysis of data after longer follow-up is needed to suggest a survival benefit for a particular dialysis modality.

Disclosures

The authors declare that they have no competing interests.

References

1 Levey AS, Beto JA, Coronado BE, *et al.* Controlling the epidemic of cardiovascular disease in chronic renal disease: what do we know? What do we need to learn? Where do we go from here? National Kidney Foundation Task Force on Cardiovascular Disease. Am J Kidney Dis 1998;32:853–906.

2 Foley RN, Parfrey PS, Sarnak MJ. Clinical epidemiology of cardiovascular disease in chronic renal disease. Am J Kidney Dis 1998;32(suppl 3):S112–19.

3 Cheung AK, Sarnak MJ, Yan G, *et al.* Cardiac diseases in maintenance hemodialysis patients: results of the HEMO Study. Kidney Int 2004;65:2380–9.

4 Sarnak MJ, Levey AS, Schoolwerth AC, *et al.* on behalf of the American Heart Association. Kidney disease as a risk factor for development of cardiovascular disease: a statement from the American Heart Association Councils on Kidney in Cardiovascular Disease, High Blood Pressure Research, Clinical Cardiology, and Epidemiology and Prevention. Circulation 2003;108:2154–69.

5 Kennedy R, Case C, Fathi R, Johnson D, Isbel N, Marwick TH. Does renal failure cause an atherosclerotic milieu in patients with end-stage renal disease? Am J Med 2001;110:198–204.

6 Isbel NM, Haluska B, Johnson DW, Beller E, Hawley C, Marwick TH. Increased targeting of cardiovascular risk factors in patients with chronic kidney disease does not improve atheroma burden or cardiovascular function. Am Heart J 2006;151:745–53.

7 Yilmaz FM, Akay H, Duranay M, *et al.* Carotid atherosclerosis and cardiovascular risk factors in hemodialysis and peritoneal dialysis patients. Clin Biochem 2007;40:1361–6.

8 Zoccali C. Traditional and emerging cardiovascular and renal risk factors: an epidemiologic perspective. Kidney Int 2006;70:26–33.

9 Kaisar M, Isbel N, Johnson DW. Cardiovascular disease in patients with chronic kidney disease. A clinical review. Minerva Urol Nefrol 2007;59:281–97.

10 Kaisar MO, Isbel NM, Johnson DW. Recent clinical trials of pharmacologic cardiovascular interventions in patients with chronic kidney disease. Rev Recent Clin Trials 2009;3:79–88.

11 Bleyer AJ, Russell GB, Satko SG. Sudden and cardiac death rates in hemodialysis patients. Kidney Int 1999;55:1553–9.

12 Moist LM, Port FK, Orzol SM, *et al*. Predictors of loss of residual renal function among new dialysis patients. J Am Soc Nephrol 2000;11:556–64.

13 Lysaght MJ, Vonesh EF, Gotch F, *et al*. The influence of dialysis treatment modality on the decline of remaining renal function. ASAIO Trans 1991;37:598–604.

14 Dikow R, Schwenger V, Zeier M, Ritz E. Do AV fistulas contribute to cardiac mortality in hemodialysis patients? Semin Dial 2002;15:14–17.

15 Johnson DW, Armstrong K, Campbell SB, *et al*. Metabolic syndrome in severe chronic kidney disease: prevalence, predictors, prognostic significance and effects of risk factor modification. Nephrology (Carlton) 2007;12:391–8.

16 Kobayashi M, Yorioka N, Yamakido M. Hypercoagulability and secondary hyperfibrinolysis may be related to abnormal lipid metabolism in patients treated with continuous ambulatory peritoneal dialysis. Nephron 1997;76:56–61.

17 Wong JS, Port FK, Hulbert-Shearon TE, *et al.* Survival advantage in Asian American end-stage renal disease patients. Kidney Int 1999;55:2515–23.

18 Goodkin DA, Bragg-Gresham JL, Koenig KG, *et al.* Association of comorbid conditions and mortality in hemodialysis patients in Europe, Japan, and the United States: the Dialysis Outcomes and Practice Patterns Study (DOPPS). J Am Soc Nephrol 2003;14:3270–7.

19 Held PJ, Brunner F, Odaka M, García JR, Port FK, Gaylin DS. Five-year survival for end-stage renal disease patients in the United States, Europe, and Japan, 1982 to 1987. Am J Kidney Dis 1990;15:451–7.

20 Uhlig K, Levey AS, Sarnak MJ. Traditional cardiac risk factors in individuals with chronic kidney disease. Semin Dial 2003;16:118–27.

21 Goodkin DA, Mapes DL, Held PJ. The dialysis outcomes and practice patterns study (DOPPS): how can

we improve the care of hemodialysis patients? Semin Dial 2001;14:157–9.
22 Yoshino M, Kuhlmann MK, Kotanko P, *et al.* International differences in dialysis mortality reflect background general population atherosclerotic cardiovascular mortality. J Am Soc Nephrol 2006;17:3510–19.
23 Huang CC, Cheng KF, Wu HD. Survival analysis: comparing peritoneal dialysis and hemodialysis in Taiwan. Perit Dial Int 2008;28(suppl 3):S15–20.
24 Chang YK, Hsu CC, Hwang SJ, *et al.* A comparative assessment of survival between propensity score-matched patients with peritoneal dialysis and hemodialysis in Taiwan. Medicine (Baltimore) 2012;91:144–51.
25 Korevaar JC, Feith GW, Dekker FW, *et al.* on behalf of the NECOSAD Study Group. Effect of starting with hemodialysis compared with peritoneal dialysis in patients new on dialysis treatment: a randomized controlled trial. Kidney Int 2003;64:2222–8.
26 Weinhandl ED, Foley RN, Gilbertson DT, Arneson TJ, Snyder JJ, Collins AJ. Propensity-matched mortality comparison of incident hemodialysis and peritoneal dialysis patients. J Am Soc Nephrol 2010;21:499–506.
27 McDonald SP, Marshall MR, Johnson DW, Polkinghorne KR. Relationship between dialysis modality and mortality. J Am Soc Nephrol 2009;20:155–63.
28 Suzuki K, Konta T, Ichikawa K, *et al.* Comparison of mortality between Japanese peritoneal dialysis and hemodialysis patients: a 5-year multicenter follow-up study. Int J Nephrol 2012;2012:231018.
29 Jaar BG, Coresh J, Plantinga LC, *et al.* Comparing the risk for death with peritoneal dialysis and hemodialysis in a national cohort of patients with chronic kidney disease. Ann Intern Med 2005;143:174–83.
30 Quinn RR, Hux JE, Oliver MJ, Austin PC, Tonelli M, Laupacis A. Selection bias explains apparent differential mortality between dialysis modalities. J Am Soc Nephrol 2011;22:1534–42.
31 Collins AJ, Hao W, Xia H, *et al.* Mortality risks of peritoneal dialysis and hemodialysis. Am J Kidney Dis 1999;34:1065–74.
32 Fenton SS, Schaubel DE, Desmeules M, *et al.* Hemodialysis versus peritoneal dialysis: a comparison of adjusted mortality rates. Am J Kidney Dis 1997;30:334–42.
33 Heaf JG, Lokkegaard H, Madsen M. Initial survival advantage of peritoneal dialysis relative to haemodialysis. Nephrol Dial Transplant 2002;17:112–17.
34 Lukowsky LR, Mehrotra R, Kheifets L, Arah OA, Nissenson AR, Kalantar-Zadeh K. Comparing mortality of peritoneal and hemodialysis patients in the first 2 years of dialysis therapy: a marginal structural model analysis. Clin J Am Soc Nephrol 2013;8:619–28.
35 Termorshuizen F, Korevaar JC, Dekker FW, Van Manen JG, Boeschoten EW, Krediet RT on behalf of the Netherlands Cooperative Study on the Adequacy of Dialysis Study Group. Hemodialysis and peritoneal dialysis: comparison of adjusted mortality rates according to the duration of dialysis: analysis of the Netherlands Cooperative Study on the Adequacy of Dialysis 2. J Am Soc Nephrol 2003;14:2851–60.
36 Soucie JM, McClellan WM. Early death in dialysis patients: risk factors and impact on incidence and mortality rates. J Am Soc Nephrol 1996;7:2169–75.
37 Winkelmayer WC, Glynn RJ, Mittleman MA, Levin R, Pliskin JS, Avorn J. Comparing mortality of elderly patients on hemodialysis versus peritoneal dialysis: a propensity score approach. J Am Soc Nephrol 2002;13:2353–62.
38 Polkinghorne KR, McDonald SP, Atkins RC, Kerr PG. Vascular access and all-cause mortality: a propensity score analysis. J Am Soc Nephrol 2004;15:477–86.
39 Dhingra RK, Young EW, Hulbert-Shearon TE, Leavey SF, Port FK. Type of vascular access and mortality in U.S. hemodialysis patients. Kidney Int 2001;60:1443–51.
40 Kim H, Kim KH, Park K, *et al*. A population-based approach indicates an overall higher patient mortality with peritoneal dialysis compared to hemodialysis in Korea. Kidney Int 2014;86:991–1000.
41 Mehrotra R, Chiu YW, Kalantar-Zadeh K, Bargman J, Vonesh E. Similar outcomes with hemodialysis and peritoneal dialysis in patients with end-stage renal disease. Arch Intern Med 2011;171:110–18.
42 van de Luijtgaarden MW, Noordzij M, Stel VS, *et al.* Effects of comorbid and demographic factors on dialysis modality choice and related patient survival in Europe. Nephrol Dial Transplant 2011;26:2940–7.
43 Vonesh EF, Snyder JJ, Foley RN, Collins AJ. The differential impact of risk factors on mortality in hemodialysis and peritoneal dialysis. Kidney Int 2004;66:2389–401.
44 Sanabria M, Munoz J, Trillos C, *et al.* Dialysis Outcomes in Colombia (DOC) study: a comparison of patient survival on peritoneal dialysis vs. hemodialysis in Colombia. Kidney Int Suppl 2008;73:S165–72.
45 Stack AG, Molony DA, Rahman NS, Dosekun A, Murthy B. Impact of dialysis modality on survival of new ESRD patients with congestive heart failure in the United States. Kidney Int 2003;64:1071–9.
46 Ganesh SK, Hulbert-Shearon T, Port FK, Eagle K, Stack AG. Mortality differences by dialysis modality among incident ESRD patients with and without coronary artery disease. J Am Soc Nephrol 2003;14:415–24.

Corresponding author:
Haitham Ezzat, MD, Nephrology Department,
Ain Shams University, Cairo 11477 Egypt.
E-mail:
haitham_ezzat@hotmail.com