Characteristics and prognostic outcome factors between young and elderly peritoneal dialysis patients: a prospective cohort study

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Background: Peritoneal dialysis (PD) is the main renal replacement therapy in elderly patients account for hemodynamic stability. The clinical characteristics and prognosis of elderly PD patients are varies in different dialysis centers. We analyzed the characteristics, outcomes and prognosis factors of survival in elderly PD patients in China, to better understand their status and improve their quality of life.

Methods: This prospective, observational study categorized 202 PD patients by age: elderly group ≥65 years, younger group <65 years. The inclusion criteria were: age >18 years, first PD treatment and dialysis time >3 months, and complete data. Clinical characteristics including demographic data, hemodynamic variables were compared between groups. After a median follow-up of 44 months, prognosis outcomes between young and elderly groups were measured. Multivariate Cox regression analysis were used to establish the models for predicting outcomes. Then the nomogram of the model was generated.

Results: A total of 202 PD patients were enrolled: 61 in the elderly group and 141 in the younger group. The comparison of baseline data revealed decreased serum albumin, normalized protein catabolic rate and higher incidence of previous cardiovascular, cerebrovascular diseases, Charlson Comorbidity Index (CCI) in the elderly group. The mortality rate was substantially higher in the elderly group. Cardiovascular disease was the main cause of death in elderly PD patients. High body mass index (BMI) [hazard ratio (HR) =1.0, 95% confidence interval (CI): 1.0–1.1, P=0.005], high CCI (HR =1.1, 95% CI: 1.0–1.2, P=0.022), and ischemic heart disease (ISD) (HR =2.5, 95% CI: 1.0–6.1, P=0.042) were risk factors for the long-term survival of elderly PD patients.

Conclusions: High BMI, high CCI and ISD were important factors for evaluating the adverse outcomes of elderly PD patients. Larger studied are needed to identify risk factors in elderly PD patients and to improve their outcomes.
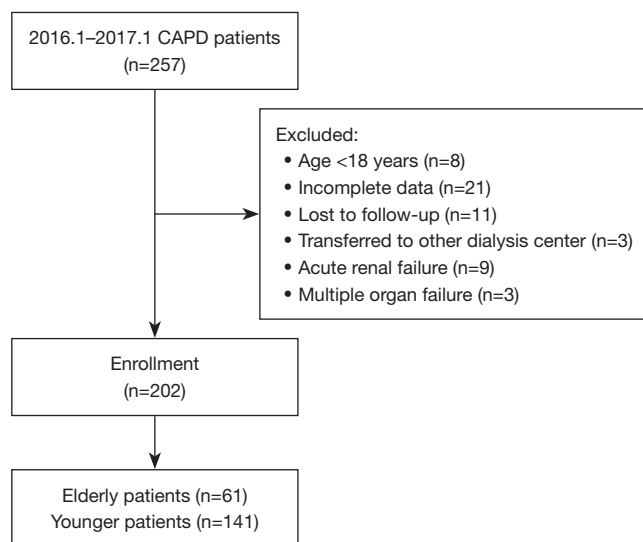
Keywords: Elderly; peritoneal dialysis (PD); death; prognosis

Introduction

Chronic kidney disease (CKD) is a global public health problem and becoming increasingly common. A survey in China found that patients with stage 3 CKD numbered almost 1.2 million in 2012, and the average age was 63.6 years (1). From its development to the end stage, peritoneal dialysis (PD) is one of the main renal replacement therapies and a better choice for elderly patients with endstage renal disease (ESRD), because of its lesser effect on hemodynamics, protection of residual renal function, low cost and simple operation (2).

In recent years, researchers from various countries have explored the risk factors of adverse outcomes of elderly PD patients. They found that elderly PD patients tended to have

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│ 2016.1–2017.1 CAPD patients │
│          (n=257)            │
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              │
              │        ┌──────────────────────────────────────────────────────┐
              │───────▶│ Excluded:                                            │
              │        │  • Age <18 years (n=8)                               │
              │        │  • Incomplete data (n=21)                            │
              │        │  • Lost to follow-up (n=11)                          │
              │        │  • Transferred to other dialysis center (n=3)        │
              │        │  • Acute renal failure (n=9)                         │
              │        │  • Multiple organ failure (n=3)                      │
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│         Enrollment          │
│          (n=202)            │
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│  Elderly patients (n=61)    │
│  Younger patients (n=141)   │
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Figure 1 Flow chart of recruitment of patient enrolment. CAPD, continuous ambulatory peritoneal dialysis.

multiple comorbidities, including diabetes, hypertension, cardiovascular and cerebrovascular diseases (3), and this combined with age and nutritional deficiency could influence their clinical outcomes (4,5). Meanwhile peritonitis is the main risk factor for withdrawal from PD, and death is the main reason for ceasing PD (6,7). However, previous studies have been mainly retrospective, and the factors influencing mortality differ across countries. There also have been few reports in China about the reasons for withdrawal from PD, especially regarding transfer to hemodialysis (HD). How to screen out risk factors with high efficiency from many clinical indicators, especially indicators that are simple to use and conducive to prevent adverse outcome in elderly PD patients, is of great clinical significance.

In this study, we analyzed the characteristics, prognosis (death, transfer to HD) of elderly PD patients by comparison with a younger group, to assess the prognostic factors in elderly CKD patients. We present the following article in accordance with the STROBE reporting checklist (available at https://apm.amegroups.com/article/view/10.21037/apm-22-1008/rc).

Methods

Study groups

The prospective cohort study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and approved by the Ethics Committee of the Cangzhou Central Hospital in Cangzhou City, Hebei Province, China [approval number: 2020-257-01(Z)]. Written informed consent was given by each of the 202 patients undergoing continuous ambulatory PD between January 2016 and January 2017 in the Department of Nephrology of Cangzhou Central Hospital. Conventional PD solutions (Dianeal 1.5%, 2.5%, or 4.25% dextrose; Baxter Healthcare, Guangzhou, China), Y-sets, and twin-bag systems were used and patients did the exchange themselves after successful training by primary care nurses. According to age, the PD patients were divided into an elderly group (age ≥65 at PD initiation) and a younger group (age <65). The inclusion criteria were: age >18 years, first PD treatment and dialysis time >3 months, and complete data. The exclusion criteria included incomplete data, loss to follow-up or uncooperative with follow-up, or transfer to another dialysis center. Additionally, we did not include patients diagnosed as acute renal failure or multiple organ failure. *Figure 1* is a flow chart of the enrolment. End of follow-up was defined as the day of the outcome (death or transfer to HD) or end of follow-up (January 2020). In this study, the mortality rate after follow-up was used as the main indicator to estimate the sample size. For two-sided test, the test level was 0.5, the degree of control was 80%, and the two groups were 1:1. According to a previous study (8), the mortality is about 56% in elderly PD patients, about 30% in young PD patients. PASS2008 was used to estimate that 53 pairs of effective patients were needed.

Demographic and clinical data

The demographic data included sex, age, body mass index (BMI), etiological diagnosis (diabetic nephropathy, hypertensive renal damage, primary glomerular disease), peritonitis or not, and bacterial culture results (gram-positive or gram-negative bacilli). We also recorded the outcomes of patients: continue PD, death, time and reason for transferring to HD, kidney transplantation, time and cause of death. The Charlson Comorbidity Index (CCI) was used to measure comorbidity (9). The following hemodynamic variables were recorded: white blood cells (WBC), red blood cells (RBC), and hemoglobin (Hb), platelets (PLT), albumin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin, direct bilirubin, serum creatinine, blood urea nitrogen, serum calcium, potassium, sodium, and ferritin, total Urea

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clearance index (Kt/V), residual Kt/V, weekly creatinine clearance rate (WCcr), residual creatinine clearance rate, normalized protein catabolic rate (nPCR), dialysis duration, use of angiotensin-converting enzyme inhibitors/angiotensin receptor blockers (ACEI/ARB), and history of cerebrovascular disease, ischemic heart disease (ISD) and heart failure (HF).

Outcomes

Data are collected through the PD telemedicine App, a web-based data collection system and medical records. Patients were followed up until death, permanent transfer to hemodialysis (defined as more than 3 months), renal transplantation, loss to follow-up, or the end of study.

Statistical analysis

Data analyses were performed using SPSS23.0 and R 3.6.1 version. Results are expressed as mean ± standard deviation (SD), median and interquartile range or number and percentages (%), as appropriate. The Kolmogorov-Smirnov test was used to examine the normality of all numeric continuous variables. Independent sample t-tests were used if with a normal distribution, and nonparametric tests (Mann-Whitney U test) were used to examine variables without a normal distribution, when comparing between groups. Categorical data were compared between the elderly and younger groups by chi-square test. When there were <5 observations in a group-outcome combination, Fisher's test was used. Kaplan-Meier survival curve analysis was performed to investigate the differences in survival and

transferring to HD between the elderly and younger groups. Multivariate Cox regression analysis was used to screen the risk factors of mortality in elderly patients. Using the backward method, the entry probability was set to 0.05, and the removal probability was set to 0.10. All tests were two-sided, and P<0.05 was considered statistically significant.

Results

General characteristics of the elderly patients

We enrolled 202 PD patients (61 in the elderly group, 141 in the younger group) with a median follow-up of 44 months. Compared with the younger group, elderly patients were more likely to have lower albumin and nPCR, and more comorbidities, especially cardiovascular and cerebrovascular diseases. Diabetic nephropathy was common in elderly group, with a statistically significant difference (P<0.01). *Table 1* shows the baseline characteristics of patients grouped by age.

Outcomes of elderly patients

To the end of the study, 121 (59.9%) patients continued to receive PD, 48 (23.8%) died, 25 (12.4%) were transferred to HD, and 8 (3.9%) underwent kidney transplantation. In the elderly group, 27 (44.3%) patients died, 2 (3.3%) were transferred to HD, and 1 (1.6%) received a kidney transplant. Due to small number of kidney transplantation patients in the elderly group, the reasons for kidney transplantation were not elaborated. *Table 2* shows the outcomes of all PD patients.

Table 1 Baseline characteristics of PD patients according to age

| Characteristics	All patients, n=202	Elderly group, n=61	Younger group, n=141	P value
Demographic data				
Age, years	57.00 (45.00, 65.00)	72.00 (66.50, 76.00)	50.00 (37.00, 57.50)	<0.001
Male, n (%)	121 (59.9)	34 (55.7)	87 (61.7)	0.427
Laboratory data				
BMI, kg/m², mean ± SD	23.97±4.33	23.92±3.54	24.00±4.64	0.903
WBC, ×10⁹/L	6.64 (5.30, 8.11)	7.13 (5.33, 9.32)	6.40 (5.26, 7.77)	0.158
RBC, ×10¹²/L, mean ± SD	3.46±0.59	3.36±0.69	3.50±0.54	0.159
Hb, g/L	102.00 (91.00, 116.00)	100.00 (85.00, 115.50)	103.00 (93.00, 116.00)	0.279

Table 1 (*continued*)

Table 1 (continued)

Characteristics	All patients, n=202	Elderly group, n=61	Younger group, n=141	P value
PLT, ×10^9/L	209.50 (163.00, 251.25)	202.00 (146.50, 252.00)	212.00 (165.00, 251.00)	0.281
ALB, g/L	33.70 (37.20, 40.10)	35.60 (32.00, 38.00)	38.40 (34.95, 41.00)	<0.001
ALT, u/L	12.60 (9.15, 17.15)	13.00 (9.80, 16.90)	12.45 (9.10, 17.38)	0.153
AST, u/L	15.80 (12.00, 20.30)	16.00 (12.10, 20.45)	15.45 (12.00, 20.15)	0.171
TBIL, µmol/L	4.10 (4.95, 6.60)	3.90 (4.50, 6.10)	4.38 (5.10, 6.60)	0.151
DBIL, µmol/L	1.70 (1.20, 2.30)	1.70 (1.20, 2.30)	1.70 (1.20, 2.30)	0.759
Scr, µmol/L	815.50 (587.50, 1,039.75)	747.00 (541.00, 979.00)	607.00 (828.00, 1,042.00)	0.253
BUN, mmol/L	19.50 (14.78, 22.93)	18.20 (13.90, 22.20)	19.90 (15.50, 23.50)	0.133
Serum Ca, mmol/L	2.16 (2.01, 2.31)	2.12 (1.96, 2.29)	2.17 (2.02, 2.33)	0.135
Serum K, mmol/L	4.20 (3.70, 4.80)	4.20 (3.60, 4.75)	4.20 (3.80, 4.80)	0.414
Serum Na, mmol/L	141.00 (138.00, 142.15)	141.00 (137.00, 143.00)	141.00 (139.00, 142.00)	0.309
Ferritin, ug/L	269.70 (137.70, 573.50)	300.00 (138.00, 514.45)	257.00 (136.25, 584.80)	0.725
Total Kt/V	1.72 (1.45, 2.04)	1.69 (1.50, 2.04)	1.73 (1.42, 2.04)	0.784
Residual Kt/V	0.08 (0.00, 0.33)	0.10 (0.01, 0.32)	0.06 (0.00, 0.34)	0.343
Total WCcr, mL/min	45.67 (39.89, 53.94)	46.09 (40.77, 55.15)	45.17 (39.58, 53.68)	0.769
Residual Ccr, mL/min	2.00 (0.00, 9.79)	2.82 (0.07, 15.07)	1.19 (0.00, 10.29)	0.235
nPCR, g/kg/day	0.82 (0.71, 0.92)	0.74 (0.62, 0.85)	0.85 (0.76, 0.93)	0.003
Dialysis time (months)	26.00 (13.00, 49.00)	21.00 (9.50, 46.00)	27.00 (14.00, 51.00)	0.279
CCI score	9.00 (5.00, 13.00)	11.00 (6.50, 15.00)	9.00 (5.00, 11.00)	0.003
Medical history, n (%)				
ISD	58 (28.7)	34 (55.7)	24 (17.0)	<0.001
HF	73 (36.1)	27 (44.3)	46 (32.6)	0.114
Cerebrovascular disease	40 (19.8)	19 (31.1)	21 (14.9)	0.008
PD-related Peritonitis	88 (43.6)	21 (34.4)	67 (47.5)	0.085
Gram-positive	32 (15.8)	10 (16.4)	22 (15.6)	0.888
Gram-negative	20 (9.9)	8 (13.1)	12 (8.5)	0.314
ACEI/ARB use	74 (36.6)	18 (29.5)	56 (39.7)	0.167
Primary disease, n (%)				
DN	46 (22.8)	22 (36.1)	24 (20.6)	0.003
HRD	27 (13.4)	11 (18.0)	16 (10.9)	0.200
CG	30 (14.9)	6 (9.8)	24 (14.8)	0.187

Data are presented as median (interquartile range), mean ± SD or frequency and percentage. PD, peritoneal dialysis; BMI, body mass index; SD, standard deviation; WBC, white blood cell; RBC, red blood cell; Hb, hemoglobin; PLT, platelet; ALB, albumin; ALT, alanine aminotransferase; AST, aspartate aminotransferase; TBIL, total bilirubin; DBIL, direct bilirubin; Scr, serum creatinine; BUN, blood urea nitrogen; Kt/V, total Urea clearance index; WCcr, weekly creatinine clearance rate; nPCR, normalized protein catabolic rate; CCI, Charlson Comorbidity Index; ISD, ischemic heart disease; HF, heart failure; ACEI/ARB, angiotensin-converting enzyme inhibitors/angiotensin receptor blockers; DN, diabetic nephropathy; HRD, hypertensive renal damage; CG, chronic glomerulonephritis.

Table 2 Outcomes of patients

Outcomes	All patients, n=202	Elderly group, n=61	Younger group, n=141
Stay on PD, n (%)	121 (59.9)	31 (50.8)	90 (63.8)
Death, n (%)	48 (23.8)	27 (44.3)	21 (14.9)
Transferred to HD, n (%)	25 (12.4)	2 (3.3)	23 (16.3)
Kidney transplant, n (%)	8 (3.9)	1 (1.6)	7 (5.0)

PD, peritoneal dialysis; HD, hemodialysis.
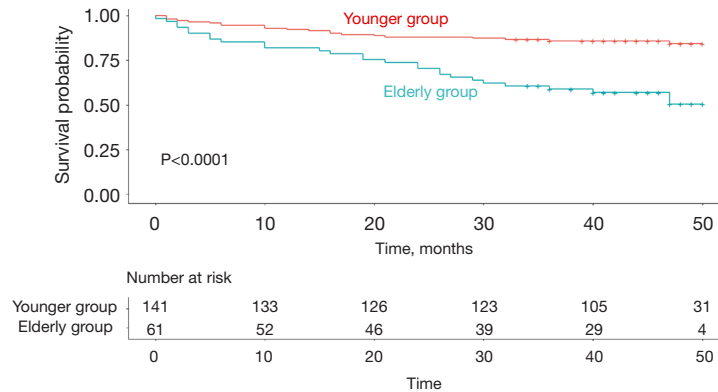
Figure 2 Kaplan-Meier survival curves according to age. Time = follow-up time (months).

Table 3 Causes of death

Death	Elderly group, cases (%)	Younger group, cases (%)
Cardiovascular disease	10 (37.0)	4 (19.0)
Cerebrovascular disease	4 (14.8)	4 (19.0)
Infection	3 (11.1)	6 (28.6)
Cachexia	3 (11.1)	2 (9.5)
Other	7 (25.9)	5 (23.8)

Table 4 Causes of transferring to HD

Transfer to HD	Elderly group, cases (%)	Younger group, cases (%)
Peritonitis	2 (3.3)	18 (12.8)
Inadequate dialysis	0	2 (1.4)
Dialysis failure	0	2 (1.4)
Others	0	1 (0.7)

HD, hemodialysis.

Mortality of PD patients

A total of 27 (44.3%) elderly patients and 21 (14.3%) younger patients died (*Figure 2*). The survival time of the elderly group was significantly lower than that of the younger group. The 1-, 2-, 3- and 4-year survival rates were 81.97%, 70.49%, 60.66% and 55.74%, respectively. The main cause of death in the elderly group was cardiovascular disease, while in younger group it was infection (*Table 3*).

Transferring to HD

A total of 2 (3.3%) elderly PD patients, and 23 (16.3%)

younger patients transferred to HD. Peritonitis was the chief reason for both elderly and younger PD patients to transfer to HD (*Table 4*).

Prognostic outcome factors in elderly PD patients

For elderly PD patients, univariate Cox regression analysis indicated that BMI, CCI, previous ISD, peritonitis, and dialysis time were risk factors for long-term survival. BMI, CCI and ISD remained independent significant predictors of long-term survival of elderly PD patients by multivariate Cox regression analysis (*Table 5*, *Figure 3*). CCI (r=0.471, P<0.001) and dialysis time (r=0.260, P=0.043) were related

Table 5 Independent relative risk of death in elderly peritoneal dialysis patients

Factor	Univariate analysis			Multivariate analysis		
	P	HR	95% CI	P	HR	95% CI
BMI	0.016	1.139	1.025–1.265	0.005	1.0	1.0–1.1
CCI	0.018	1.073	1.012–1.137	0.022	1.1	1.0–1.2
ISD	0.011	3.084	1.301–7.315	0.042	2.5	1.0–6.1
Peritonitis	0.042	2.305	1.031–5.154	0.284	N/A	N/A
Dialysis time	0.089	1.014	0.998–1.030	0.310	N/A	N/A

BMI, body mass index; CCI, Charlson Comorbidity Index; ISD, ischemic heart disease; HR, hazard ratio; CI, confidence interval; N/A, not available.
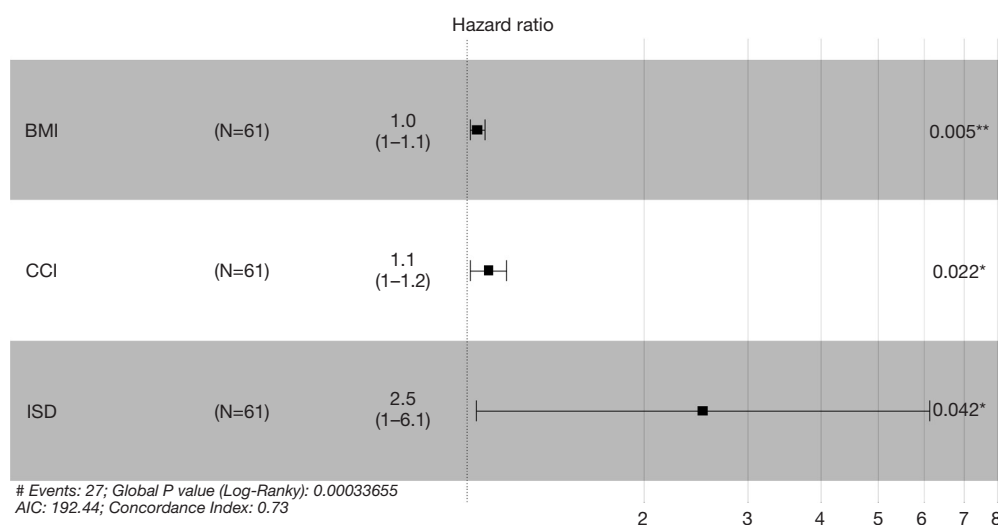
Figure 3 Independent relative risk of death in elderly peritoneal dialysis patients by multivariate analysis. *P<0.05; **P<0.005. BMI, body mass index; CCI, Charlson Comorbidity Index; ISD, ischemic heart disease.

to peritonitis and may be confounding factors.

Discussion

Both the aging of the population and the outbreak of COVID-19 have led to increased rates of ESRD and the number of elderly patients needing PD (10). In order to improve the prognosis and quality of life in elderly patients with PD, we need to understand the factors influencing their survival and actively prevent and control these risk factors.

In the present study, we analyzed the general condition of elderly CKD patients, the reasons for withdrawal from PD therapy, and the risk factors for survival to provide guidance for improving prognosis and prolonging the survival time of patients with ESRD on PD.

Compared with the younger group, the elderly group of PD patients tended to have hypoalbuminemia and low nPCR, both of which are important indicators of the nutrition of patients (11), and our finding was consistent with the study by Khoshhali et al. (12). Wang et al. also reported that serum albumin remained lower in elderly patients (13). During PD, nutrients are lost in the dialysis solution, and the absorptive capacity of gastrointestinal tract is decreased in elderly patients, leading to malnutrition. Arteriosclerosis and cardiovascular and cerebrovascular events often occur with diabetic nephropathy (14,15), and age is also a risk factor of vascular calcification (16). Because PD does not require vascular access and has less effect on hemodynamics, elderly patients prefer PD. Although it

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has been reported that elderly PD patients are inclined to develop peritonitis (17), there was no difference in the incidence of peritonitis between the elderly and younger groups in this study, which was consistent with a Canadian study that reported elderly PD patients aged ≥70 years old had no relationship with peritonitis (18), considering they had better family and social support and were treated with advanced antibiotics.

In our study, the mortality rate of younger patients on PD was significantly lower than that of the elderly patients. Age is a risk factor for the survival of PD patients (4,19). The 1-, 2-, 3- and 4-year survival rates of elderly PD patients were 81.97%, 70.49%, 60.66% and 55.74%, respectively. Another study in China found that the 1-, 3-, and 5-year mortality rates of elderly patients with PD were respectively 79%, 56% and 30% (19), which is generally consistent with our results. Cardiovascular disease is the leading cause of death; 53.4% of elderly PD patients had cardiovascular complications in a retrospective study (8). The US Renal Data System data showed that cardiovascular events were the main cause of death in dialysis patients (20), which was related to metabolic abnormalities and the increased incidence of diabetic nephropathy in elderly PD patients.

Our study results provide evidence that high BMI, high CCI and ISD are independent risk factors for death in elderly PD patients. Patients with high BMI have a high risk of dialysis (21), and obesity can increase the incidence of cardiovascular and cerebrovascular events, thus increasing the risk of death (22). However, the relationship between BMI and survival in elderly patients with PD is controversial. Some studies found that obese PD patients lived longer or for the same time as those with lower BMI (23,24), considering that patients with lower BMI will have increased protein consumption and thus inflammation, and high BMI can increase hemodynamic stability and the isolation of fat tissue from toxins (25). Another study found that baseline BMI was not related to the prognosis of PD (26), so more studies are needed to explore the relationship between BMI and death in elderly PD patients. As mentioned, CCI is an important index of complications. Genestier *et al.* showed that CCI positively correlated with death in elderly patients (27). A retrospective analysis of 292 patients found the 2-year survival rate of elderly patients with CCI score >9 was 38%, and that of patients with CCI <7 reached 69% (28). Elderly PD patients often have ISD, and thus the risk of recurrence of cardiovascular and cerebrovascular events increases (29), so elderly PD patients are at high risk of death.

In this study, peritonitis was main reason for transferring to HD in both elderly and younger patients. Li *et al.* (30) and Banno *et al.* (31) also found that the main reason for transferring to HD was peritonitis. The number of elderly patients transferring to HD was less than that of younger patients. Although elderly patients had a higher risk of peritonitis-related and all-cause death. In a recent study from Brazil, the only factor associated with death during peritoneal infection was older age (32), so the elderly patients had no chance to transfer to HD.

This study elucidated the characteristics of elderly PD patients, their prognosis and the prognostic factors for death, which will help nephrologists improve the prognosis of these patients. However, this study had some limitations. First, it was a single-center, relatively small sample study, which cannot represent the situation of all elderly PD patients in China. Therefore, additional multicenter studies are needed in larger populations to confirm the conclusions of our study. In addition, we did not analyze the economic and social status of each patient.

Conclusions

Compared with a younger group, elderly PD patients had poor nutritional status, more complications, a high proportion of diabetic nephropathy and high mortality. High BMI, high CCI and previous ISD were independent risk factors of death of elderly PD patients. Cardiovascular disease was the main cause of death in elderly group. Peritonitis was major reason for PD patients transferring to HD.

Acknowledgments

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://apm.amegroups.com/article/view/10.21037/apm-22-1008/rc

Data Sharing Statement: Available at https://apm.amegroups.com/article/view/10.21037/apm-22-1008/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://apm.amegroups.com/article/view/10.21037/apm-22-1008/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Ethics Committee of the Cangzhou Central Hospital in Cangzhou City, Hebei Province, China [approval number: 2020-257-01(Z)]. Written informed consent was given by each of patients.

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