Correlations between gender, age and the risk of withdrawal from peritoneal dialysis

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Research article

Keywords: Peritoneal Dialysis, Technique Survival, Age, Sex, Cox Proportional Hazards Model

Posted Date: May 8th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-25404/v1>

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Abstract

Background With the increasing incidence of end stage renal disease(ESRD),peritoneal dialysis(PD) has become the preferred method of kidney replacement therapy for an increasing number of patients with end stage renal disease due to its many advantages.The intent of this study was to explore the correlations between sex, age and risk of withdrawal from peritoneal dialysis.

Methods All patients who underwent PD catheterization and initiated PD at Wuhan No.1 Hospital between 2013 and 2018 were screened.Clinical information of these patients was collected and compared according to gender and age,then was applied to the Cox proportional hazards model to determine the impact of factors of withdrawal from peritoneal dialysis.

Results Hazard ratios(HRs) of withdrawal of PD associate with gender and age at initiation were 0.736($P = 0.289$)1.151($P = 0.489$)respectively.Nonetheless,male patients under 60 years old had a 1.58-fold higher risk of withdrawal than others($HR\ 0.63, P = 0.031$).The withdrawal risk of patients with total Creatinine clearance rate (Ccr) above 60L/W was 82.4% higher than that of patients who did not meet the standard ($HR\ 1.82, P = 0.005$).The withdrawal risk of patients with high D/P Creatinine/Cr value which was calculated from peritoneal equilibration test(PET) were 2.06 times higher than low-average and high-average transport patients($HR\ 2.06, P = 0.008$).Patients with serum albumin above 35 g/L were intended to withdraw from PD than those below 35 g/L ($HR\ 0.56, P = 0.006$).

Conclusions There were significant differences in total KT/V, total Ccr,serum creatinine(Scr) and blood Urea nitrogen(BUN)among patients with PD of different gender and age.The analysis showed that male patients under 60 years old, Ccr, value of D/Pcr and serum albumin had a high correlation with the technical survival rates.While gender or age at PD initiation were not associated with technique survival,male patients under 60 years old had a 1.58-fold higher risk of withdrawal from PD than others.The outcome that the withdrawal risk of patients with Ccr above 60L/W was 82.4% higher than other patients who did not meet the standard suggested that Ccr was not suitable as an index for evaluating the adequacy of PD,especially for men under 60 years old.And patients with high D/Pcr value or with serum albumin under 35 g/L were related risk factors for technique survival.

Background

Epidemiological data shows that the prevalence of chronic kidney disease (CKD) worldwide is 8–16%^[1], while in China the prevalence is 10.8%^[2].CKD has become one of the most urgent public health problems that needs to be solved all over the world due to its long course of disease,diverse etiology and complicated treatment.Subsequently,the incidence of ESRD has increased obviously with the increasing rate of CKD.Thus,peritoneal dialysis, which has the advantages of lower price, simpler equipment,more convenient operation,smaller impacts on hemodynamics,lower cross-infection rate,less impacts on work and life,and more favorable for the protection of residual renal function^[3] compared with hemodialysis(HD),has become the preferred renal replacement therapy for more and more patients with

ESRD. Here, we aimed to explore the different characteristics of gender and age in some indicators of peritoneal dialysis, as well as the risk factors of technique survival, in order to find relevant strategies to further improve the survival rate of peritoneal dialysis.

Methods

Patients and study design

A total of 380 patients with ESRD who underwent surgical PD catheter placement and started continuous ambulatory peritoneal dialysis (CAPD) treatments more than 3 months at the peritoneal dialysis center of Wuhan No.1 Hospital from January 1, 2013 to December 31, 2018 were analyzed retrospectively. Forty three patients were excluded due to age below 18 years old at PD initiation, PD duration less than 3 months or missing data. Finally, 337 patients were identified and included in the study. Among them, 167 were males (49.55%). The mean age of patients at the start of CAPD was 53.55 ± 13.70 years old. Except for gender and age, other clinical information regarding time of starting CAPD, numbers of dialysate bags, primary diseases and so on were collected. As it was showed in table 1, there was no statistically significant difference in age at PD initiation or numbers of dialysate bags, but PD duration of male patients was less than that of female patients and male patients had a higher proportion of complication of diabetes mellitus (DM) than females.

Table 1 Comparison of Patients' Basic Information by Gender Group

Baseline	Male (N = 167)	Female (N = 170)	P-value
^a Age at PD initiation(years)	52.89 $\pm$ 13.76	54.21 $\pm$ 13.66	0.541
^b PD duration(months)	23.00 (13.00, 39.00)	29.00 (16.00, 46.25)	0.037*
^c Diabetes mellitus	20.36%	11.76%	0.032*
^b Numbers of dialysate bags(bags)	4.00 (4.00, 4.00)	4.00 (3.00, 4.00)	0.149

Datas were presented as mean $\pm$ SD or median; a. Unpaired t-test is used for normally distributed datas; b. Non-parametric test is adopted for datas do not conform to normal distribution; c. Chi-square test is used for categorical datas; * P-value < 0.05, Δ P-value < 0.01; The following was still applicable if not marked.

Data collection

The peritoneal equilibration test^[5] was carried according to the standard operating procedures of peritoneal dialysis (2010), dialysis fluid and blood samples were collected at 0h, 2h and 4h respectively after peritoneal retention, and D/P Cr value was calculated by using the ratio of creatinine of Peritoneal dialysate to serum creatinine. Indexes related to dialysis and biochemical examination were measured by automatic analyzer in our hospital, including hemoglobin, serum albumin, electrolytes, urea nitrogen and

creatinine,then calculating^[5]total creatinine clearance (Ccr) and total urea clearance index (KT/V) per week.

Statistical analyses

Statistical analyses was performed using SPSS version 24.0(SPSSInc,Chicago,IL,USA)software.Categorical data were described as proportions.Quantitative data were reported as the mean ± standard deviation (SD)(datas conforming to the normal distribution) or as median or quartiles,as appropriate.For comparison between two groups, Independent-Samples T test was used for data conforming to normal distribution, otherwise Mann-Whitney Test was used.As for comparison among multiple groups, Analysis of Variance was used for datas which met the normal distribution and homogeneity of variance;or else Nonparametric Test was used.In pairwise comparison among multiple groups, BonferroniTest was used for data of homogeneity of variance, and Nonparametric Test for others.In table 4-1 to 4-9the data of “PD KT/V”“Total KT/V”“Serum Albumin”“Urea Nitrogen”“Blood Scale”and“Parathyroid Hormone(PTH)” were analyzed by Bonferroni Test;the data of “residual kidney Ccr”“total Ccr”and “serum creatinine”were analyzed by Nonparametric Test.Death,kidney transplant or transferring to HD was used as the end point for the analysis of patient when analyzing technique survival. The risk factors for technique survival was analyzed with a multivariate Cox’s proportional-hazard model in which we included all the significant variables from the univariate analysis and variables which were considered clinically relevant according to the current literature. Differences were considered statistically significant for P values less than 0.05.

Results

Of the 337 CAPD patients in the study, 167 (49.55%) were males. The mean age at the start of PD was 53.55 ± 13.70 years old. Chronic glomerulonephritis was the most common cause of ESRD (45.99%), followed by diabetes mellitus (16.02%), hypertension (15.13%),obstructive nephropathy (5.64%), systemic lupus erythematosus (3.56%), and other causes. By the end of event, 30(8.9%) patients died,11 (3.2%) patients received renal transplantation,59 (17.4%) patients switched to hemodialysis237 (70.3%) patients continued undergoing PD.

Patients outcomes

Comparing the differences of indicators in patients with peritoneal dialysis by genderwe could learn from table 2 that the data of male patients were higher than that of female patients in residual renal Ccr, peritoneal Ccr, total creatinine clearance rate, D/P Cr, urea nitrogen and blood creatinine. However, female patients had advantages over male patients in the aspect of peritoneal dialysis KT/V, total KT/V and serum calcium.

Table 2 Comparison of different genders in various indicators

Indicator	Male(N = 167)	Female(N = 170)	T/Z	P
^b KT/V of residual kidney	0.20(0.00,0.48)	0.23(0.00,0.57)	0.243	0.808
^a KT/V of PD	1.21 + / - 0.34	1.77 + / - 0.41	13.468	0.000 [△]
^b Total KT/V	1.47(1.29,1.72)	2.12(1.73,2.40)	9.911	0.000 [△]
^b Ccr of residual kidney(L/W)	13.15(0.00,31.82)	9.24(0.00,21.18)	2.502	0.012 [*]
^b Ccr of PD(L/W)	45.65(37.88,51.28)	41.47(35.01,48.00)	2.894	0.004 [△]
^b Total Ccr(L/W)	58.49(50.30,75.06)	51.86(44.32,64.48)	4.195	0.000 [△]
^b PET (D/P value)	0.67 (0.57, 0.75)	0.61 (0.57, 0.69)	2.152	0.031 [*]
^a Hb (g/L)	102.99 + / - 19.03	101.71 + / - 19.12	0.614	0.540
^b Serum albumin (g/L)	35.60(32.70,38.80)	35.70(32.30,38.80)	0.546	0.585
^b BUN(mmol/L)	18.00(14.30,21.90)	15.95(12.48,20.03)	3.252	0.001 [△]
^a Scr (mumol /L)	991.26 + / - 338.08	824.56 + / - 221.92	5.341	0.000 [△]
^b Serum kalium (mmol/L)	4.00 (3.50, 4.50)	4.10 (3.60, 4.60)	0.594	0.552
^a Serum calcium (mmol/L)	2.20 + / - 0.24	2.26 + / - 0.24	2.538	0.012 [*]
^a Serum phosphate (mmol/L)	1.56 + / - 0.51	1.53 + / - 0.48	0.530	0.596
^b Serum ferritin (mug /L)	202.10(103.80,362.40)	182.20(89.50,349.58)	0.959	0.338
^b PTH (pg/ml)	222.60(117.10,440.20)	291.95(118.03,518.53)	1.512	0.130

Subsequently, divided all the patients into four groups to estimate the differences of each group in various indicators. Group A included male patients whose age were less than 60 years old(109 cases),group B included female patients whose age were under 60 years old (102 cases),group C included male patients whose age were more than 60 years old(58 cases),group D included female patients whose age were more than 60 years old(68 cases), respectively.

Table 3 Comparison of four groups of ABCD in each indicator

Project	Group A	Group B	Group C	Group D	F	P
^e KT/V of residual kidney	0.20	0.24	0.21	0.21	0.164	0.920
^d KT/V of PD	1.20±0.33	1.83 ± 0.40	1.24 ± 0.36	1.68±0.42	63.354	0.000 ^Δ
^e Total KT/V	1.48	2.19	1.45	2.05	34.340	0.000 ^Δ
^e Ccr of residual kidney(L/W)	13.74	9.24	12.42	9.29	3.528	0.016 [*]
^e Ccr of PD(L/W)	46.10	42.14	44.11	40.12	2.478	0.061
^e Total Ccr (L/W)	59.54	52.19	55.71	50.24	5.724	0.001 ^Δ
^e PET(D/P value)	0.66	0.62	0.67	0.61	2.090	0.104
^e Hb (g/L)	105.00	102.00	98.50	100.50	0.710	0.547
^e Serum albumin (g/L)	37.20	36.20	34.50	34.50	4.896	0.002 ^Δ
^e BUN(mmol/L) (mmol/L)	19.27±5.98	16.80±5.51	16.96 ±5.40	15.49 ±5.44	7.095	0.000 ^Δ
^e Scr (μmol /L)	1048.56 ±338.96	887.38 ± 207.13	883.57±311.60	730.34 ± 221.02	19.237	0.000 ^Δ
^e Serum kalium(mmol/L)	4.10	4.15	3.85	4.00	1.295	0.276
^d Serum calcium (mmol/L)	2.19 ± 0.24	2.27± 0.24	2.21 ±0.23	2.25±0.23	2.297	0.077
^d Serum phosphate(mmol/L)	1.62± 0.49	1.64 ± 0.48	1.43 ±0.52	1.35 ±0.43	6.963	0.000 ^Δ
^e Serum ferritin (μg /L)	210.30	177.85	188.20	202.45	0.761	0.517
^e PTH (pg/ml)	278.70	319.00	193.60	212.95	2.860	0.037 [*]

d. Analysis of Variance is used for datas which meet the normal distribution and homogeneity of variance; e. Non-parametric test is adopted for datas do not conform to normal distribution or homogeneity of variance.

As it showed in table 3,the indicators of peritoneal of KT/V,total KT/V, residual renal Ccr, total Ccr,serum albumin, urea nitrogen, blood creatinine,blood phosphorus and PTH had statistical differences.Thus,the above indicators were further compared and analyzed to obtain table 4-1 to 4-9.The data in the follow tables showed the average difference of any two groups of A to D.

Table 4-1 Comparison of four groups in PD KT/V

J	Group A	Group B	Group C	Group D
I				
Group A	-	0.629 Δ	0.047	0.484 Δ
Group B	0.629 Δ	-	0.582 Δ	0.146
Group C	0.048	0.582 Δ	-	0.436 Δ
Group D	0.484 Δ	0.146	0.436 Δ	-

Table 4-1 showed the data of PD KT/V of female patients was higher than that of male patients at any age.

Table 4-2 Comparison of four groups in total KT/V

J	Group A	Group B	Group C	Group D
I				
Group A	-	0.592 Δ	0.036	0.489 Δ
Group B	0.592 Δ	-	0.556 Δ	0.104
Group C	0.036	0.556 Δ	-	0.452 Δ
Group D	0.489 Δ	0.104	0.452 Δ	-

As it showed in table 4-2, the data of total KT/V of female patients at any age was higher than that of male patients.

Table 4-3 Comparison of four groups in residual renal Ccr

J	Group A	Group B	Group C	Group D
I				
Group A	-	11.485*	2.312	9.490
Group B	11.485*	-	9.173	1.995
Group C	2.312	9.173	-	7.178
Group D	9.490	1.995	7.178	-

Table 4-3 showed that the residual renal Ccr of male patients under 60 years old was higher than that of female patients of the same age group.

Table 4-4 Comparison of four groups in total Ccr

J	Group A	Group B	Group C	Group D
I				
Group A	-	13.881 Δ	4.516	14.609 Δ
Group B	13.881 Δ	-	9.365	0.729
Group C	4.516	9.365	-	10.094
Group D	14.609 Δ	0.729	10.094	-

Table 4-4 showed that the total creatinine clearance rate of male patients under 60 years old was higher than that of female patients at any age.

Table 4-5 Comparison of four groups in serum albumin

J	Group A	Group B	Group C	Group D
I				
Group A	-	1.046	2.809*	1.982
Group B	1.046	-	1.763	0.935
Group C	2.809*	1.763	-	0.828
Group D	1.982	0.935	0.828	-

As it showed in table 4-5, the level of serum albumin of male patients under 60 years old was significantly higher than that of male patients over 60 years old.

Table 4-6 Comparison of four groups in blood urea nitrogen

J	Group A	Group B	Group C	Group D
I				
Group A	-	2.467*	2.310	3.778 Δ
Group B	2.467*	-	0.156	1.311
Group C	2.310	0.156	-	1.468
Group D	3.778 Δ	1.311	1.468	-

Table 4-6 showed that the data of blood urea nitrogen in male patients under 60 years old was higher than that of female patients at any age.

Table 4-7 Comparison of four groups in serum creatinine

J	Group A	Group B	Group C	Group D
I				
Group A	-	161.177 Δ	164.991*	318.224 Δ
Group B	161.177 Δ	-	3.813	157.044 Δ
Group C	164.991*	3.813	-	153.231*
Group D	318.221 Δ	157.044 Δ	153.231*	-

Table 4-7 showed that the data of serum creatinine of male patients younger than 60 years old was higher than that of female patients at any age, as well as male patients older than 60 years old. While female patients younger than 60 years old had higher level of it than that of same-sex patients older than 60 years old. Nonetheless the data of serum creatinine of male patients older than 60 years old was significantly higher than that of female patients.

Table 4-8 Comparison of four groups in blood phosphorus

J	Group A	Group B	Group C	Group D
I				
Group A	-	0.024	0.186	0.269 Δ
Group B	0.024	-	0.210	0.293 Δ
Group C	0.186	0.210	-	0.083
Group D	0.269 Δ	0.293 Δ	0.083	-

It could be seen from table 4-8 that the level of blood phosphorus of male and female patients younger than 60 years old was higher than that of female patients older than 60 years old.

Table 4-9 Comparison of four groups in PTH

J I	Group A	Group B	Group C	Group D
Group A	-	63.590	82.573	38.652
Group B	63.590	-	146.162*	102.242
Group C	82.573	146.162*	-	43.920
Group D	38.652	102.242	43.920	-

Table 4-9 showed that the data of PTH of female patients younger than 60 years old was higher than that of male patients older than 60 years old.

Taking all of the above into account,we can draw conclusions as follows: The value of peritoneal dialysis KT/V of female patients was significantly higher than that of male patients,as well as total KT/V,no matter what age. The data of creatinine clearance rate (Ccr), blood urea nitrogen BUN and the serum creatinine Scr of male patients under 60 years old was higher than that of female patients at any age. The patients under 60 years old had higher level of Scr than that of same-sex people who was beyond 60 years old,while the data of Scr of male patients was higher than that of female in the same-age group. The P/D Cr value of female patients was lower than that of male patients.

These results indicated that there were differences in the biochemical indexes of patients divided into groups by gender and age,especially for those male patients younger than 60 years old. Therefore,what was the correlation between gender,age and the risk of exit from PD? Taking death,kidney transplant or transferring to hemodialysis as the end of event to analyze technique survival,gender,age at the beginning of dialysis,male patients with age less than 60 years old,primary disease,total KT/V,total creatinine clearance,PET,Hb,serum albumin,serum kalium,calcium,serum phosphate,serum ferritin,and PTH were taken as the independent variables (details in table 5).

Table 5 Assignment of risk factors for technique survival

Factors	Assignment instructions
Age at PD initiation	< 60 years =0, ≥60 years =1
Gender	Male =0, female =1
PD duration	month
Male patients with age under 60 years old	Yes =0, no =1
Primary disease	Glomerulonephritis =0, hypertension =1, obstructive nephropathy =2, lupus =3, diabetes =4, others =5
Degree of education	Primary or middle school =0, high school =1, college or above =2, illiteracy =3
Region	Suburban =0, urban =1, other=2
Payment method	Urban employees' medical insurance=0, Urban residents' medical insurance=1, New cooperative medical scheme=2, Self-paying and others =3
Ending	Endpoint event =0, truncation =1
KT/V	< 1.7= 0, ≥1.7 = 1
Total Ccr	< 60 L/W = 0, ≥60L/W = 1
PET(D/Pvalue)	0.5-0.81 = 0,0.3-0.49=1,0.82-1.03=2
Scr	≤991.26μmol/L=0,≥991.26μmol/L=1
BUN	≤18.00mmol/L=0,≥18.00mmol/L=1
Hb	≤100g/L=0,≥100g/L=1
Serum albumin	≤35g/L=0,≥35g/L=1
Serum kalium	3.5-5.3mmol/L=0,3.5mmol/L=1, ≥5.3mmol/L=2
Serum calcium	2.00-2.80mmol/L=0,2.00mmol/L=1,≥2.80mmol/L=2
Serum phosphate	0.80-1.50mmol/L=0,0.80mmol/L=1,≥1.50mmol/L=2
Serum ferritin	100ug/L-500ug/L=0,100ug/L=1,500ug/L=2
PTH	150ug/L-600ng/L=0,150ng/L=1,600ng/L=2

Taking all these factors into univariate Cox analysis,the results showed that gender,male patients with age under 60 years old,primary disease,total Ccr,PET,serum albumin and serum calcium had statistically significant effects on the technical survival rate of CAPD patients.Subsequently,these factors and other variables which are considered clinically relevant according to the current literaturewere were introduced into the Cox regression model for multi-factor analysis.

Table 6 Patient technique survival by Univariate and Multivariate Cox Proportional Hazards Analysis

Variable		Univariate			Multivariate		
		HR	95.0%CI	P	HR	95.0%CI	P
Age at the time of dialysis initiation		1.151	0.773-1.716	0.489			
Gender	male	1			1		
	female	0.625	0.420-0.929	0.020*	0.736	0.417-1.298	0.289
Male patients with age under 60 years old		0.607	0.406-0.909	0.015*	0.633	0.418-0.960	0.031*
Primary disease	chronic glomerulonephrit	1			1		
	hypertension	1.268	0.700-2.298	0.434	0.984	0.375-2.584	0.974
	obstructive nephropathy	1.072	0.454-2.532	0.874	2.828	0.987-8.099	0.053
	systemic lupus erythematosus	2.331	0.917-5.928	0.076	1.001	0.534-1.877	0.999
	diabetes	1.816	1.059-3.113	0.030*	1.212	0.592-2.481	0.599
	others	1.136	0.618-2.088	0.682	0.971	0.458-2.060	0.940
Degree of education	primary or middle school	1					
	high school	0.622	0.363-1.066	0.084			
	university and above	1.079	0.637-1.827	0.779			
	illiteracy	0.933	0.374-2.330	0.883			
Region	suburban	1					
	urban	0.932	0.616-1.409	0.737			
	other	0.344	0.083-1.430	0.142			
Payment method	urban workers' insurance	1					

	urban residents' insurance	0.775	0.282-2.130	0.621			
	Rural cooperative medical service	0.892	0.564-1.410	0.625			
	self-paying and others	0.280	0.069-1.142	0.076			
KT/V		0.796	0.536-1.183	0.259			
Total Ccr		2.088	1.396-3.125	0.000 Δ	1.824	1.203-2.764	0.005 Δ
PET(D/Pvalue)	0.5-0.81	1			1		
	0.3-0.49	1.045	0.481-2.268	0.911	1.165	0.535-2.537	0.701
	0.82-1.03	2.759	1.647-4.620	0.000 Δ	2.060	1.209-3.512	0.008 Δ
Scr		0.726	0.475-1.110	0.139			
BUN		1.390	0.938-2.061	0.101			
Hb		0.776	0.523-1.153	0.209			
Serum albumin		0.527	0.355-0.784	0.002 Δ	0.563	0.373-0.851	0.006 Δ
Serum kalium (mmol/L)	3.5-5.3	1					
	< 3.5	0.582	0.310-1.093	0.092			
	5.3 or higher	1.484	0.685-3.215	0.317			
Serum calcium (mmol/L)	2.00-2.80	1			1		
	< 2.00	1.884	1.182-3.005	0.008 Δ	1.559	0.963-2.525	0.071
	2.80 or higher	1.388	0.192-10.033	0.745	2.148	0.293-15.733	0.452
Serum phosphate(mmol/L)	0.80-1.50	1					
	< 0.80	2.210	0.934-5.225	0.071			
	1.50 or higher	1.122	0.744-1.693	0.582			

Serum ferritin (ug/L)	100-500.	1		
	< 100	1.084	0.695- 1.690	0.722
	> 500	1.375	0.764- 2.474	0.288
PTH (ng/L)	150-600.	1		
	< 150	0.887	0.572- 1.377	0.594
	> 600	0.575	0.314- 1.053	0.073

HR=1 indicated the column was as a reference.

In the Cox proportional hazard model, patients' gender or age at PD initiation were not the risk factors of patient technique survival in our study. Nonetheless, male patients less than 60 years old had a 1.58-fold higher risk of withdrawal than other patients. The withdrawal risk of patients with total Ccr above 60L/W was 82.4% higher than that of patients who did not meet the standard. The withdrawal risk of patients with high D/P Cr value which was calculated from PET were 2.06 times higher than those low-average and high-average patients. Additionally, patients with the data of serum albumin above 35 g/L was easier to withdraw from PD than those people whose level of serum albumin was below 35g/L.

Discussion

Peritoneal dialysis is a widely used method for end stage renal disease. There have been some literatures shown that the early life quality of CAPD patients is significantly better than that of hemodialysis patients in many aspects^{[6][7]}. Thus, exploring the correlations between sex, age and risk of technique survival might be helpful with the design of dialysis prescription for different clinical populations and prolonging the duration of sustainable treatment. There are different opinions about the effects of gender and age on the technical survival of PD patients. Chidambaram M et al.^[8] considered that aging was an important factor affecting the survival of patients. A single-center study done in South Korea^[9] demonstrated that young age was a significant independent factor associated with long term PD maintenance, but gender was not. Zhang F et al.^[10] studied the survival of 421 PD patients and found that the survival of patients was related to age. In addition, there were several studies^{[8][11]} indicating gender had no correlations with technology failure. Kitterera D^[12] in the study of 745 patients with peritoneal dialysis failure and the relationship between gender found that the technical survival rate of female was significantly higher than that of male patients which is the same conclusion as Dr Shen JI^[13] and Liu X's research^[14]. Moreover, in the analysis of risk factors related to outcomes of peritoneal dialysis patients from Taiwan, Chen HL^[15] also found the risk of technical failure of female patients was significantly lower when evaluating

the clinical treatment effect on PD patients. In our retrospective analysis, the results of multi-factor COX regression analysis showed that gender or age at PD initiation (60 years old as the boundary) were not relevant risk factors for CAPD patients to withdraw, while male patients under 60 years old had a 1.58-fold higher risk of withdrawal from PD than other patients.

The results of our study also suggested the total creatinine clearance rate and blood creatinine of male patients younger than 60 years old were higher than those of females at any age, furthermore the withdrawal risk of patients with total Ccr above 60L/W was 82.4% higher than patients who did not meet the standard. In the study on the relationship between serum creatinine and gender in healthy people, Cao Dan et al.^[16] found that the level of serum creatinine of men was higher than that of women in the same age. Besides, in the study on the relationship between serum creatinine and gender in peritoneal dialysis patients, Zhao Huanjia^[17] found that age, gender and BMI were independent factors affecting the level of serum creatinine. The level of serum creatinine was decreasing with the increasing of age, of which male patients were higher than that of female patients. This finding was consistent with our study of relationship between gender and the serum creatinine, and the reasons underlying the result might be multifactorial, in brief, the serum creatinine concentration mainly depends on muscle creatine phosphate decomposing and kidney producing. Our retrospective study suggested that the level of serum creatinine of male patients less than 60 years old was significantly higher than that of female patients at any age, and the ability to remove creatinine was significantly better than that of female patients. While the risk of withdrawal from PD was 82.4% higher than that of other patients whose total creatinine clearance rate did not reach 60L/W, in the case that the clearance rate of residual renal creatinine was equal. Considering that previous dialysis guidelines suggested that KT/V should be no less than 1.7 and Ccr should be more than 60L/1.73 m²^[5], we held the opinion that Ccr reaching 60L/1.73 m² was not clinically appropriate as an evaluation index of dialysis adequacy in male patients under 60 years old.

In our study, the multivariate Cox proportional hazards model showed that the level of serum albumin was a relevant risk factor for CAPD patients to withdraw from treatment. Chen HL^[15], Griva K^[18], Wang J^[19], et al. found that lower serum albumin levels were associated with an increased risk of technical failure in analysis of risk factors related to PD patients. The results of our analysis showed that the withdrawal risk of patients with serum albumin above 35 g/L was 43.7% lower than that of patients below 35 g/L. Although there was no statistically significant difference in serum albumin between male and female patients when compared by gender as a whole, the level of serum albumin of male patients under 60 years old was significantly higher than that of male patients over 60 years old. It was suggested that nutritional issues, namely albumin levels, was not the reason why men younger than 60 years old withdrawl from peritoneal dialysis.

In addition, our study demonstrated peritoneal transport characteristics were the relevant factors affecting the technical survival of CAPD patients. The withdrawal risk of patients with high value of D/P Cr of peritoneal equilibrium test (PET) were 2.06 times higher than those low-average and high-average patients, while patients with low transport of PET had no statistical differences in the risk of dropping out.

Just as Li Han^[20] believed that the Ccr of patients with low transport were not easy to reach 60L/1.73 m², while its technical survival rate were not low but even exceed that of patients with high transport. A study from Japan^[21] also demonstrated the value of high P/D Cr was also associated closely with higher mortality and failure of peritoneal dialysis. Our study compared different gender groups which suggested that the values of P/D Cr of male patients were higher than that of female patients on average, which was consistent with the findings found by Lin tao^[22] that male gender was a risk factor for high peritoneal transport status. In addition, our study also suggested KT/V of male patients were significantly lower than female patients at any age. It told us that men had disadvantages over women in peritoneal transport characteristics and urea scavenging index. Especially for male patients younger than 60 years old, we speculated the reason why such patients were more likely to withdraw from peritoneal dialysis was related to their high peritoneal transport characteristics and insufficient clearance of small molecules of CAPD. In the future, automated peritoneal dialysis (APD) could be further observed to explore the survival rate of peritoneal dialysis in male patients younger than 60 years old.

There were still some limitations in our study. The retrospective analysis of single-center small sample size limited the investigation and information collection of the whole peritoneal dialysis population. Besides, no suitable indicators for the evaluation of peritoneal sufficiency in male patients younger than 60 years old had been found. Therefore it is necessary to further explore the reasons for easily withdrawal of male patients who are younger than 60 years old and design a more appropriate prescription for peritoneal dialysis patients to improve their technique survival rate.

Conclusions

In summary, the study implied that patients with high D/Pcr value or with serum albumin under 35 g/L were related risk factors for technique survival, and male patients who are under 60 years old had a higher risk of withdrawal from PD. The outcome also suggested that Ccr above 60L/W was not suitable as an index for evaluating the adequacy of PD, especially for men under 60 years old.

Abbreviations

BUN: Blood Urea nitrogen; CKD: Chronic kidney disease; Cr: Creatinine; Ccr: Creatinine clearance rate; CAPD: Continuous ambulatory peritoneal dialysis; DM: Diabetes mellitus; ESRD: End-stage renal disease; HD: Hemodialysis; Hb: Hemoglobin; HR: Hazard ratios; KT/V: Urea clearance index; PD: Peritoneal dialysis; PET: Peritoneal equilibration test; PTH: Parathyroid hormone; Scr: Serum creatinine

Declarations

Acknowledgments

The authors thank all of members in the PD center of Wuhan NO·1 Hospital for their careful management of PD patients constantly and for their help in conducting this study.

Authors'Contributions

ZYM and HM contribute equally to the manuscript.ZYM and XF conceived and designed the study.HM,WS,DYQ collected the data.HM and LL analyzed the data,ZYM and HM prepared tables and figures,and wrote the manuscript.HYL polished the article with the translation.All authors read and approved the final manuscript.

Funding

None.

Availability of data and materials

The data supporting the findings of this study were used under license for the current study and are not publicly available.However,with a reasonable request,the author can provide the data.

Ethics approval and consent to participate

This study was approved by the Wuhan No.1 Hospital Ethics Committee Review Board and written informed consent was exempt due to its retrospective nature.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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