Original Article

Risk factors of cardiac complications in patients with end-stage renal disease undergoing maintenance peritoneal dialysis

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Background: Cardiovascular disease (CVD) is the most frequent cause of death in patients on maintenance peritoneal dialysis (PD). This study aimed to identify the risk factors associated with cardiac complications and establish a multivariate logistic regression model for cardiac complications in patients with end-stage renal disease (ESRD) requiring PD.

Methods: This retrospective study included 232 patients undergoing PD. Data of sociodemographic information, comorbidities, medication history, laboratory examination, and medical history were extracted from the medical records of patients with ESRD who underwent maintenance PD between January 2015 and June 2020. Multivariate logistic regression analysis was performed to determine the independent risk factors.

Results: The mean age of the study participants was 51.29±13.17 years, with female: male ratio of 87:145. Multivariate logistic regression analysis indicated that lactate dehydrogenase (odds ratio, 1.002; 95% confidence interval, 1.001–1.004; P=0.004), albumin (odds ratio, 0.947; 95% confidence interval, 0.914–0.982; P=0.003), and left atrial diameter (odds ratio, 1.096; 95% confidence interval, 1.037–1.159; P=0.001) were independent risk factors associated with cardiac complications. The area under the receiver operating characteristic curve was 0.78.

Conclusions: We identified the risk factors of cardiac complications in patients with ESRD requiring PD, which may be clinically useful to assess patients in PD and start their early treatment, which can help improve their prognosis.

Keywords: Maintenance peritoneal dialysis; cardiovascular risk; end-stage renal disease (ESRD); comorbidities

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Introduction

End-stage renal disease (ESRD) is the most severe stage of chronic kidney disease, and the risks of morbidity and mortality associated with ESRD have increased immensely worldwide (1), which, in turn, considerably increase the medical costs and global healthcare burden (2,3). More than 2 million patients have been receiving therapy for ESRD globally, and the prevalence of ESRD is expected to rise enormously in the future (1). Renal replacement therapy remains the only effective treatment when the disease

worsens to ESRD. Moreover, dialysis is the primary therapy for ESRD as the scarcity of donors limits the possibility of kidney transplantation. However, severe complications are frequently encountered among patients despite undergoing maintenance dialysis, which is a reasonably effective treatment (4). The patients living with maintenance dialysis and cardiovascular complications have significantly increased morbidity and risk of mortality (5). The incidence of cardiovascular death in such patients is 5–25 times higher than that in the general population (6).

Peritoneal dialysis (PD) is an important therapeutic modality for patients with ESRD (7). A previous study indicated that the overall adjusted incidence of 1-year survival in patients on PD was 86.8%, and the incidence of 10-year survival was 11.3% (8). The decrease in the survival rate of patients on PD over time is robustly associated with multifaceted factors (7). Furthermore, cardiovascular disease (CVD) is the most frequent cause of death among patients on PD (9). Therefore, risk factors for CVD in this patient population need to be assessed and early interventions should be designed to improve the prognosis of patients with ESRD. This retrospective study was designed to identify the risk factors associated with cardiac complications in patients undergoing PD. We present the following article in accordance with the STROBE reporting checklist (available at https://apm.amegroups.com/article/view/10.21037/apm-21-2987/rc).

Methods

Study design and patient data collection

This was a single-centre, observational, retrospective study, in which all data were extracted from the medical records of patients with ESRD who underwent maintenance PD between January 2015 and June 2020 in the PD centre of Lixin People's Hospital. A total of 232 patients were included in the study. The inclusion criteria were as follows: age ≥18 years, previously underwent maintenance PD (duration: >6 months), and diagnosis of ESRD. The exclusion criteria were as follows: refusal to follow-up, and missing follow-up data.

Data collection

Data on sociodemographic characteristics, concomitant diseases, treatment drugs, laboratory examination, and medical history were collected from the electronic medical records of patients, and all these data was before the data of their first PD. The following variables was analysed: age; sex; marital status (married/widowed or bachelor); educational level (under high school/high school or above); systolic and diastolic blood pressure; coronary artery disease; hypertension; diabetic nephropathy; diabetes mellitus; history of stroke; medication history of calcium channel blockers, diuretics, beta-blockers, calcium supplements, antiplatelet drugs, and insulin; and laboratory data of serum uric acid, chlorine, hemoglobin, alanine transaminase, aspartate aminotransferase, alkaline phosphatase, albumin, blood urea nitrogen, creatinine, β2-microglobulin, potassium, sodium, calcium, phosphate, fasting blood-glucose, triglyceride, total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), C-reactive protein (CRP), creatine kinase, lactate dehydrogenase, creatine kinase isoenzyme, ferritin, D-dimer, total iron-binding capacity, transferrin, parathyroid hormone, folic acid, and erythrocyte and leukocyte counts. We also retrieved the data of Doppler echocardiography: left ventricular ejection fraction (LVEF), left atrial diameter, pulmonary arterial hypertension and checked for any findings of ST-segment depression in the electrocardiography data.

Endpoints and outcome assessment

The primary outcome variable was the occurrence of cardiac complications in the first 6 months of PD. Cardiac complications including acute heart failure, incidence of cardiac death, unstable angina, myocardial infarction, cardiovascular comorbidity, and cardiovascular hospitalisation were evaluated in the analysis.

Statistical analysis

Data are presented as number (%) or mean ± standard deviation. Continuous variables were evaluated using the *t*-test or Mann-Whitney U test, and categorical variables were evaluated using the χ^2 or Fisher exact test for analysing the intergroup differences. Statistical significance was set at $P<0.05$. All variables were examined by univariate analysis, and variables with $P<0.100$ in the univariate analysis were included in a multivariate logistic regression model. Multivariate logistic regression analysis was performed to determine the independent risk factors that could precisely predict the cardiac complications.

The performance of the multivariate logistic regression

model was evaluated using the receiver operating characteristic (ROC) curve. All statistical analyses were conducted using IBM SPSS 24.0 (IBM Corporation, Armonk, New York, USA) and R statistical software (version 4.0.5; http://www.Rproject.org).

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Medical Ethics Committee of the Lixin People's Hospital (approval No. LXH-2021T001) and individual consent for this retrospective analysis was waived.

Results

A total of 232 patients who fulfilled the inclusion criteria between January 2015 and June 2020 were enrolled (Figure S1). The included participants had an average age of 51.29±13.17 years, with female-to-male ratio of 87:145, and 119 patients had cardiac complications. The description of categorical variables in our study is shown in Table S1. In our study data, some variables have incomplete data, and the baseline characteristics of patients are shown in Table S2.

Data of variables with P<0.100 in the univariate analysis, including hemoglobin, albumin, serum calcium, creatine kinase, lactate dehydrogenase, creatine kinase isoenzyme, D-dimer, left atrial diameter, sex, coronary artery disease, hypertension, diuretics, antiplatelet drugs, diabetic nephropathy, diabetes mellitus, and use of insulin, were included in a multivariate logistic regression model (*Table 1*). We identified lactate dehydrogenase [odds ratio (OR), 1.002; 95% confidence interval (CI), 1.001–1.004; P=0.004], albumin (OR, 0.947; 95% CI, 0.914–0.982; P=0.003), and left atrial diameter (OR, 1.096; 95% CI, 1.037–1.159; P=0.001) as independent risk factors for cardiac complications (*Table 2*). We plotted the ROC curve to assess the performance of the multivariate logistic regression model and calculated the area under the ROC curve (AUROC) to obtain the AUROC score. The AUROC was 0.78 (*Figure 1*).

Discussion

In our study, we focused on finding and assessing the independent risk factors for cardiac complications in PD patients. From the overall analysis, lactate dehydrogenase, albumin, and left atrial diameter were determined as the independent risk factors for cardiac complications in the PD population. In addition, the area under the curve score of the multivariate logistic regression model was 0.78. Our results may help clinicians to assess patients with ESRD on maintenance PD and prepare for their timely interventions, which would help improve their prognosis.

The level of serum albumin is an important marker to assess the status of nutritional in ESRD patients (10,11). Previous studies indicated that low serum albumin level was strongly associated with mortality and had a prognostic value for major adverse events (12-15). Therefore, albumin levels could contribute to risk profiling and identifying the relative cardiorenal factors in patients undergoing PD. Our results suggest that albumin is an independent risk factor for cardiac complications in patients undergoing PD, which is consistent with the findings of previous studies. The level of low serum albumin may be a consequence of ESRD and not a cause, but it was associated with the adverse outcomes of patients in PD.

Previous studies have reported that the majority of dialysis patients have left ventricular hypertrophy and dysfunction, which are critical cardiac complications that may occur in patients on PD (16,17). When the left atrial diameter of patients on PD was compared over time, a significant difference was noted (18). The left atrial diameter may precisely reflect the left ventricular diastolic function in patients undergoing PD (19). Likewise, in the present study, the left atrial diameter was found to be an independent risk factor for cardiac complications, which may provide a useful basis for clinical studies. Furthermore, lactate dehydrogenase was reported as a significant risk factor of cardiac complications. However, we believe that further high-quality studies are warranted to verify these findings.

Prediction models of cardiac risk factors have been frequently used (20-23), which has improved the clinical outcomes of patients. The prediction model for cardiovascular mortality can contribute to enact specific interventions (24); however, there is a lack of related study to determinate the risk factors of cardiac complications for patients on maintenance PD. In our study, we determined the risk factors of cardiac complications in patients undergoing PD. This may help provide early treatments and ameliorate the clinical outcomes of such patients. To identify the high-risk patients undergoing PD, cardiovascular risk stratification is a crucial step for their assessment; thus, early initiation of interventions and therapy can help decrease the cardiovascular morbidity and

Table 1 Univariate analysis for risk factors of cardiac complications (P value <0.100)

Variables	Total	No cardiac complications (N=113; 48.7%)	Cardiac complications (N=119; 51.3%)	P value
Hemoglobin (g/L)	232 (100%)	90.74±19.94	86.16±18.86	0.055
Albumin (g/L)	232 (100%)	38.33±8.09	34.45±8.33	<0.001
Serum calcium (mmol/L)	232 (100%)	1.97±0.28	1.91±0.27	0.080
Creatine Kinase (IU/L)	232 (100%)	190.21±233.53	269.84±262.08	<0.001
Lactate dehydrogenase (IU/L)	232 (100%)	262.92±136.76	408.51±377.47	<0.001
Creatine kinase isoenzyme (IU/L)	232 (100%)	14.49±8.18	20.50±33.84	0.019
D-dimer (mg/L)	232 (100%)	0.55±0.83	0.85±1.29	0.010
Left atrial diameter (mm)	232 (100%)	31.35±5.34	34.60±5.66	<0.001
Sex	232 (100%)			0.019
Male		62 (42.8%)	83 (57.2%)	
Female		51 (58.6%)	36 (41.4%)	
Coronary artery disease	232 (100%)			0.031
Yes		4 (23.5%)	13 (76.5%)	
No		109 (50.7%)	106 (49.3%)	
Hypertension	232 (100%)			0.023
Yes		99 (46.5%)	114 (53.5%)	
No		14 (73.7%)	5 (26.3%)	
Diuretic	232 (100%)			0.074
Yes		26 (39.4%)	40 (60.6%)	
No		87 (52.4%)	79 (47.6%)	
Antiplatelet drugs	232 (100%)			0.080
Yes		6 (30.0%)	14 (70.0%)	
No		107 (50.5%)	105 (49.5%)	
Diabetic nephropathy	232 (100%)			0.002
Yes		8 (24.2%)	25 (75.8%)	
No		105 (52.8%)	94 (47.2%)	
Diabetes mellitus	232 (100%)			0.002
Yes		11 (26.8%)	30 (73.2%)	
No		102 (53.4%)	89 (46.6%)	
Use of insulin	232 (100%)			0.002
Yes		10 (25.6%)	29 (74.4%)	
No		103 (53.4%)	90 (46.6%)	

Data were N (%) or mean ± standard deviation. Continuous variables used Mann-Whitney U test and categorical variables used chi-squared test for comparing the baseline characteristics of patients with cardiac complications and without cardiac complications.

Table 2 Multivariate logistic regression analysis for risk factors of cardiac complications

Variables	B	OR	95% CI, lower	95% CI, upper	P value
Lactate dehydrogenase	0.002	1.002	1.001	1.004	0.004
Albumin	−0.054	0.947	0.914	0.982	0.003
Left atrial diameter	0.092	1.096	1.037	1.159	0.001

B, partial regression coefficient; OR, odds ratio; CI, confidence interval.

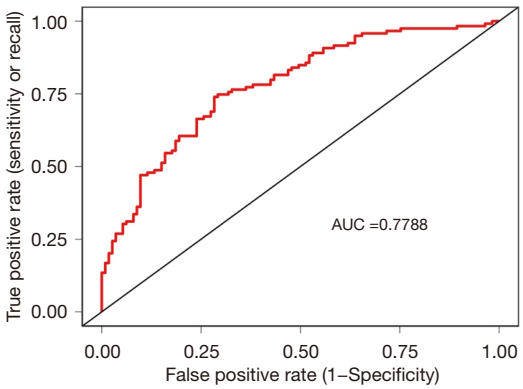

Figure 1 Receiver operating characteristic curve for the multivariate logistic regression model. Area under the receiver operating characteristic curve for the model was 0.7788.

mortality (25).

The present study had some limitations. First, data on some biomarkers of laboratory tests, such as homocysteine and troponin, were lacking; moreover, the laboratory data were incomplete for some patients, potential confounders may be present in the data, which may have affected our findings. Second, the retrospective, observational nature of the study might have negatively affected its quality. Third, the sample size of this study was relatively small because the data were collected from a single hospital, which may be unable to perform regression model to capture potential risk factors. Lastly, the duration of follow-up was 6 months; hence, studies with long-term follow-up are warranted in future to verify our findings.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://apm.amegroups.com/article/view/10.21037/apm-21-2987/rc

Data Sharing Statement: Available at https://apm.amegroups.com/article/view/10.21037/apm-21-2987/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://apm.amegroups.com/article/view/10.21037/apm-21-2987/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). This study was approved by the Medical Ethics Committee of the Lixin People's Hospital (approval No. LXH-2021T001) and individual consent for this retrospective analysis was waived.

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Supplementary

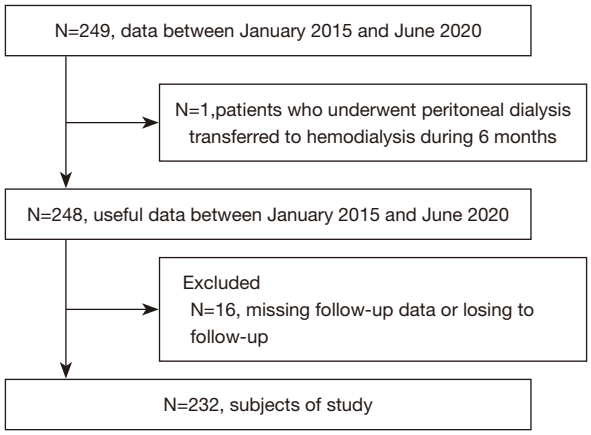

Figure S1 Flow chart of the study.

Table S1 Description of categorical variables of the study

Variable	Definition
Marital status	Marital status (Married / Widowed or bachelor).
Sex	Male or Female, reference: male.
Educational level	Educational level (Under high school/ High school or above).
Hypertension	Hypertension Status (Yes/No), reference: no.
CAD	Presence of coronary artery disease (Yes/No), reference: no.
Calcium channel blocker	Use of calcium-channel antagonist (Yes/No).
Diuretic	Use of diuretic (Yes/No), reference: no.
Beta-blocker	Use of β-receptor-blocking agent (Yes/No).
Calcium supplement	Use of calcium supplement (Yes/No).
Antiplatelet drugs	Use of antiplatelet drugs (Yes/No), reference: no.
Diabetes mellitus	Parental Diabetes History (Yes/No), reference: no.
Diabetic nephropathy	Presence of diabetic nephropathy (Yes/No), reference: no.
Use of insulin	Use of insulin (Yes/No), reference: no.
History of stroke	History of stroke (Yes/No).
ST - segment depression	ECG determined ST - segment depression (Yes, No).
PAH	Doppler echocardiography determined pulmonary arterial hypertension (Yes/No).

CAD, coronary artery disease; PAH, pulmonary arterial hypertension.

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Table S2 Baseline Characteristics of Patients

Variables	Total (%)	No cardiac complications	Cardiac complications	P value
Age (years)	232	49.95±12.95	52.57±13.30	0.129
Systolic blood pressure (mmHg)	232	160.94±25.89	165.06±26.87	0.236
Diastolic blood pressure (mmHg)	232	90.13±14.84	93.98±20.00	0.124
Erythrocyte (10*12/L)	232	3.01±0.66	2.91±0.66	0.234
Uric acid (umol/L)	199	456.56±144.63	456.25±125.93	0.987
Serum chlorine (mmol/L)	232	102.43±4.55	103.03±6.30	0.401
Hemoglobin (g/L)	232	90.74±19.94	86.16±18.86	0.055
Leukocyte (10*9/L)	232	6.27±1.94	6.85±2.54	0.152
Alanine transaminase (IU/L)	229	18.38±14.42	20.33±20.90	0.723
Aspartate aminotransferase (IU/L)	230	20.93±9.55	22.32±13.23	0.683
Alkaline phosphatase (IU/L)	230	276.70±854.14	351.76±1358.32	0.290
Albumin (g/L)	232	38.33±8.09	34.45±8.33	<0.001
Urea nitrogen (mmol/L)	232	29.81±10.04	28.69±12.49	0.173
Creatinine (umol/L)	232	851.52±302.30	866.77±434.36	0.583
β2- micro globulin (mg/L)	128	29.12±15.95	24.49±11.70	0.223
Serum potassium (mmol/L)	232	5.44±6.01	4.67±0.85	0.529
Serum sodium (mmol/L)	232	151.79±122.22	138.90±12.33	0.169
Serum calcium (mmol/L)	232	1.97±0.28	1.91±0.27	0.080
Serum phosphate (mmol/L)	232	2.01±1.29	2.20±1.78	0.424
Fasting blood-glucose (mmol/L)	232	6.02±1.95	5.91±1.90	0.896
Triglyceride (mmol/L)	227	1.65±0.88	1.54±0.77	0.295
Total cholesterol (mmol/L)	229	4.85±1.56	4.89±1.57	0.827
HDL-C (mmol/L)	229	1.33±0.69	1.89±6.55	0.805
LDL-C (mmol/L)	229	2.54±0.90	2.73±1.12	0.321
C-reaction protein (mg/L)	232	10.43±24.76	8.93±16.03	0.147
Creatine Kinase (IU/L)	232	190.21±233.53	269.84±262.08	<0.001
Lactate dehydrogenase (IU/L)	232	262.92±136.76	408.51±377.47	<0.001
Creatine kinase isoenzyme (IU/L)	232	14.49±8.18	20.50±33.84	0.019
Serum ferritin (umol/L)	232	15.04±6.71	13.92±6.78	0.223
D-dimer (mg/L)	232	0.55±0.83	0.85±1.29	0.010
Total iron binding capacity (umol/L)	174	42.83±9.31	40.59±10.06	0.131
Transferrin (g/L)	108	1.95±0.40	31.12±101.40	0.484
Parathyroid hormone (pg/mL)	190	480.19±324.61	490.13±464.17	0.667
Folic acid (nmol/L)	156	17.37±19.55	33.77±120.59	0.180
LVEF (%)	232	55.85±9.21	55.06±8.99	0.532
Left atrial diameter (mm)	232	31.35±5.34	34.60±5.66	<0.001
Sex	232			0.019
Male		62(42.8%)	83(57.2%)	
Female		51(58.6%)	36(41.4%)	
Marital status	232			1.000
Married		108(48.6%)	114(51.4%)	
Widowed or bachelor		5(50.0%)	5(50.0%)	
Educational level	232			0.556
Under high school		102(48.1%)	110(51.9%)	
High school or above		11(55.0%)	9(45%)	
Coronary artery disease	232			0.031
Yes		4(23.5%)	13(76.5%)	
No		109(50.7%)	106(49.3%)	
Hypertension	232			0.023
Yes		99(46.5%)	114(53.5%)	
No		14(73.7%)	5(26.3%)	
Calcium channel blocker	232			0.112
Yes		101(47.2%)	113(52.8%)	
No		12(66.7%)	6(33.3%)	
Diuretic	232			0.074
Yes		26(39.4%)	40(60.6%)	
No		87(52.4%)	79(47.6%)	
Beta-blocker	232			0.713
Yes		26(51.0%)	25(49.0%)	
No		87(48.1%)	94(51.9%)	
Calcium supplement	232			0.483
Yes		17(43.6%)	22(56.4%)	
No		96(49.7%)	97(50.3%)	
Antiplatelet Drugs	232			0.080
Yes		6(30.0%)	14(70.0%)	
No		107(50.5%)	105(49.5%)	
Diabetic nephropathy	232			0.002
Yes		8(24.2%)	25(75.8%)	
No		105(52.8%)	94(47.2%)	
Diabetes mellitus	232			0.002
Yes		11(26.8%)	30(73.2%)	
No		102(53.4%)	89(46.6%)	
Use of insulin	232			0.002
Yes		10(25.6%)	29(74.4%)	
No		103(53.4%)	90(46.6%)	
History of stroke	232			0.316
Yes		5(35.7%)	9(64.3%)	
No		108(49.5%)	110(50.5%)	
ST - segment depression	232			0.178
Yes		47(43.9%)	60(56.1%)	
No		66(52.8%)	59(47.2%)	
Pulmonary arterial hypertension	232			0.238
Yes		17(40.5%)	25(59.5%)	
No		96(50.5%)	94(49.5%)	

Data were N (%) or mean±standard deviation. Continuous variables used T-test or Mann-Whitney U test and Categorical variables used chi-squared test or Fisher's exact test for comparing the baseline characteristics of patients with cardiac complications and without cardiac complications.

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