Retrospective Analysis of Multi-Center Peritoneal Dialysis-Associated Peritonitis in Jiangsu Province: A Retrospective Analysis from 2016 to 2024

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Abstract

Objective: Exploring the incidence of peritoneal dialysis-associated peritonitis (PDAP) and its influencing factors in Jiangsu Province. **Methods:** An analysis was conducted on a cohort of 392 individuals undergoing peritoneal dialysis (PD) in a retrospective manner from 1 Jan. 2016 to 31 Nov. 2024 in three hospitals in southern (Nantong), northern (Xuzhou) and central (Yancheng) Jiangsu Province, and the incidence of PDAP from 1 Nov. 2023 to 31 Nov. 2024. This study collected basic information, social and environmental factors, medical factors, infection-related factors, dialysis-related factors and complications PD patients through the online system of three hospitals, and through face-to-face communication during patients follow-up collected patients' anxiety, depression, mental resilience, sleep quality and cognitive function through scales. Pearson correlation analysis was used for continuous variables and rank variables, a T-test was used to compare means between two groups, while one-way ANOVA was applied for comparisons across multiple groups, least significant difference method (LSD) was used for pound-wise comparison when variance was homogeneous, and Games-Howell method was used when variance was uneven. Multiple stepwise regression method was used to analyze the influence of risk factors on the incidence of PDAP. **Results:** The occurrence rate of PDAP was 0.31 episodes/patient-year. Mono-factor analysis showed that: dialysate bags/24 hrs (t=-4.375, P<0.001), serum potassium (t=5.001, P<0.001), serum albumin (t=4.934, P<0.001), alanine aminotransferase (ALT) (t=2.175, P=0.032), triglyceride (t=-2.399, P=0.019), total score of MMSE (t=6.502, P<0.001), educational background (χ^2=12.065, P=0.007), PD patients with catheter and tunnel exit infection (χ^2=61.128, P<0.001) and diabetes mellitus (DM) (χ^2=15.527, P<0.001) had statistical significance on the occurrence of PDAP (P<0.05). The results of logistic regression analysis were: serum potassium (odds ratio[OR], 0.403; 95% confidence interval[95%CI], 0.240-0.677), serum albumin (OR, 0.892; 95%CI, 0.833-0.956), triglyceride (OR, 1.780; 95%CI, 1.356-2.377), catheter and tunnel exit infection (OR, 62.267; 95%CI, 7.916-489.787), DM (OR, 3.360; 95%CI, 1.363-8.282) and total score of MMSE (OR, 0.737; 95%CI, 0.637-0.853) were risk factors for PDAP. **Conclusions:** Serum potassium, serum albumin, triglyceride, total score of MMSE, PD patients with catheter and tunnel exit infection and DM were independent risk factors for the incidence of PDAP, but the effects of triglyceride and number of 24-hour dialysis bag on PDAP still need to be further investigated.

Keywords: Peritoneal Dialysis, Peritonitis, Incidence, Risk Factors, Complications, Serum Potassium, Serum Albumin, Triglyceride, Diabetes, Cognitive Function.

Introduction

"The 2023 Global Kidney Disease Health Atlas Report" published by the International Society of Nephrology estimates that 850 million people worldwide suffer from chronic kidney disease (CKD), making it a major public health issue.[1] As CKD advances, cases of end-stage renal disease (ESRD) continue to rise annually. The primary therapy for end-stage renal disease (ESRD) is renal replacement therapy (RRT), comprising hemodialysis(HD), peritoneal dialysis(PD) and kidney transplantation.[2] However, due to the shortage of kidney resources, difficulties in matching and high cost, dialysis is currently the most widely used means to treat ESRD, and PD has been widely used in the world,

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particularly in developing nations, PD is favored for its simplicity, safety, and suitability for home-based treatment.[3] Globally, around 272,000 patients receive PD, accounting for 11% of the global dialysis patient demographic.[4] According to the Chinese National Renal Data System (CNRDS), as of December 31, 2023, China had 807,000 registered dialysis patients, with 140,500 receiving PD.[5]

Literature Review

PDAP stands as the most prevalent complication in PD patients and is a principal contributor to the inefficacy of PD treatment. The occurrence of this complication will lead to changes in peritoneal structure of patients, increase hospitalization, financial burden and death risk of patients, and is rated as the most critical indicator in the standardized prognosis plan of peritoneal dialysis nephropathy by PD patients, nursing staff and clinicians.[3] According to the survey conducted by Marshall et al., the global average incidence of peritonitis is 0.3 times/patient·year, among which the Asia-Pacific region has the greatest prevalence of peritonitis.[7] At present, the occurrence rate of peritonitis in large PD centers in China ranges from 0.175 to 0.198 episodes/patient·year.[8] Jiangsu Province is a region with relatively developed medical resources in China. Studies have shown that the incidence of PDAP in Jiangsu Province is 0.23-0.35 episodes/patient·year,[9,10] and the incidence varies greatly among different hospitals in different regions. Although peritonitis has a mortality rate of less than 5%, peritonitis is still one of the leading causes of death in PD patients, accounting for about 16%.[11]

There are many and complex risk factors leading to PDAP,[12-16] some of which are uncontrollable factors, such as age, gender, race, combined cardiopulmonary disease, etc. Some are controllable factors, such as social and environmental factors, medical factors, dialysis-related factors, etc.[12-15] In addition, studies have shown that psychological and cognitive dysfunction are independent risk factors for PDAP patients.[15, 16] Although there are many studies on the risk factors for incidence of PDAP, further studies are needed on the construction of clinical prediction models (CPMs) for PDAP and optimization of patient self-management.

This study analyzed the occurrence of PDAP in three hospitals in Nantong, Xuzhou and Yancheng, Jiangsu Province, and investigated the impact of uncontrollable variables including age and gender, social and environmental elements, medical conditions, factors related to dialysis, and psychological and cognitive aspects on the occurrence of PDAP patients. To provide scientific basis for the subsequent construction of PDAP clinical prediction models and optimization of patient self-management.

Subjects and Approach

Research Objectives

General Objectives

To identify risk factors leading to PDAP in Jiangsu Province, China.

Specific Objectives

To determine the prevalence of PDAP in Jiangsu Province, China.

To identify the effects of modifiable factors, including social and environment factors, medical factors, dialysis-related factors and infection-related factors, towards PDAP in Jiangsu Province, China.

To identify the effects of non-modifiable factors, including basic information, complications, climate of PD patients' living, towards PDAP in Jiangsu Province, China.

Research Questions

The current study sought to seek the answers to the following research questions.

What are the prevalence of PDAP in Jiangsu Province, China.

How the modifiable risk factors affect PDAP in Jiangsu Province, China.

How the non-modifiable risk factors affect PDAP in Jiangsu Province, China.

Hypotheses of Research

H1: There is a relationship between social and environment factor and the incidence of PDAP.

H2: There is a relationship between medical factors and the incidence of PDAP.

H3: There is a relationship between dialysis-related factors and the incidence of PDAP.

H4: There is a relationship between infection-related factors and the incidence of PDAP.

H5: There is relationship between complications and the incidence of PDAP.

Research Participants

A retrospective analysis gathered data from 1 Jan. 2016 to 31 Nov. 2024 in three Grade III hospitals in southern (Nantong), central (Yancheng) and northern (Xuzhou) of Jiangsu Province. Inclusion criteria:(1) PD patients who regularly follow-up ≥3 months; (2) Age ≥18 years old; (3) Have certain reading and communication skills; (4) Complete baseline data; (5) Volunteer take part in the research. Exclusion criteria:(1) Age<18 years old; (2) Having a history of malignancy; (3) Illiterate; (4) Difficulty communicating; (5) Blindness or deafness; (6) Performing other renal replacement therapy before or during PD; (7) Unwilling to participate the research. 392 PD patients from Nantong 160 patients, Yancheng 98 patients and Xuzhou 134 patients. The research was approved by the Ethic Committee of the hospital(LS-2024-100). All subjects provided informed consent and signed a written agreement.

Research Approach

Instrumentation

The General Data Questionnaire

It was designed by the investigator and included three parts: patient's basic information, medical factors, complications, dialysis-related factors and infection-related factors of PD patients. The basic information included patient's gender, age, weight, BMI, nationality,

marital status, working status, annual income, education background, medical insurance status, whether smoking, whether keeping pets at home, the time of each visit to the PD center for follow-up. Medical factors including serum calcium, serum potassium, serum phosphorus, hemoglobin, serum albumin, C-reactive protein (CRP), intact parathyroxine (iPTH), alanine aminotransferase (ALT), cholinesterase, triglyceride, creatinine, creatine kinase, alkaline phosphatase, uric acid, blood urea nitrogen (BUN). Complications including diabetes mellitus (DM), cardiovascular disease (CVD), cerebrovascular disease (CBVD), systemic lupus erythematosus (SLE), secondary hyperparathyroidism (SHPT), pituitary tumors, anemia, gout. Dialysis-related factors including dialysis method, dialysis duration, dialysate bags/24hrs, catheter placement method, home operator, and whether HD is used in combination. Infection-related factors including pulmonary infection, intestinal infection, catheter and tunnel exit infection.

The Questionnaire of Psychological State of PD Patients

The questionnaire includes three parts: the Self-Rating Anxiety Scale (SAS), the Self-Rating Depression Scale (SDS), and the Connor-Davidson Resilience Scale (CD-RISC). The SAS, developed by Professor Zung in 1971, assesses a patient's anxiety over the past week.[17] It includes 20 items scored on a 4-point scale: 1 (rarely), 2 (sometimes), 3 (often), and 4 (always). Five items (5, 9, 13, 17, 19) are reverse-scored. Based on Chinese norms, a standard score of 50 is the cut-off, with scores of 50–59 indicating mild anxiety, 60–69 moderate anxiety, and 70 or above severe anxiety.[18] The SDS, created by Professor Zung in 1965, evaluates depression and includes 20 items (10 positive and 10 reverse-scored). It uses the same scoring system as the SAS.[19] According to Chinese norms, a standard score of 53 is the cut-off, with 53–62 representing mild depression, 63–72 moderate depression, and 73 or above severe depression.[18] The CD-RISC, designed by Connor and Davidson in 2003[20] and later adapted by Yu and Zhang[21], measures psychological resilience. It includes 25 items across three dimensions: resilience (items 11–22), self-strength (items 1, 5, 7–10, 24, 25), and optimism (items 2–4, 6). Each item is scored from 0 (never) to 4 (always), with a total score ranging from 0–100. Higher scores indicate greater resilience, categorized as low (0–56), medium (57–70), or high (71–100)."[21]

The Pittsburgh Sleep Quality Index (PSQI)[22]

It was compiled in 1989 by Dr. Buysse *et al*.[22] a psychiatrist at the University of Pittsburgh, and was mainly used to assess the sleep quality of patients in the last 1 month. It consists of 19 self-rated items and 5 other rated items, of which the 19th self-rated item and 5 other rated items do not participate in the scoring. The 18 items involved in the score have a total of seven components, the total score ranges from 0 to 21 points, the higher the score, the worse the quality of sleep.

Mini-Mental State Examination(MMSE)[23]

It was developed in 1989 by Dr. Buysse and colleagues at the University of Pittsburgh, which assesses sleep quality for the past month consists of 19 items rated by the individual and 5 items rated by an observer., though only 18 self-rated items contribute to the score. All the items are grouped into seven components, the overall score varies from 0 to 21. Higher scores reflecting poorer sleep quality.

Data Collection

The general information of patients was exported through the online system of each hospital, and the psychological and sleep scales of PD patients were issued paper questionnaires by uniformly trained investigators on the spot, and the same guidance language was used to help patients complete the questionnaires. 400 questionnaires were distributed and fully collected, achieving 100% response rate. After excluding 8 incomplete questionnaires, 392 were deemed valid, resulting in an effective rate of 98%. The patient's mental state was assessed by uniformly trained clinical medical staff.

Data Analysis

Statistical analysis was carried out utilizing SPSS 29. Characteristics data are expressed as $\bar{x} \pm s$ and percentage. Pearson correlation analysis was used for continuous variables and rank variables, a T-test was used to compare means between two groups, while one-way ANOVA was applied for comparisons across multiple groups, least significant difference method (LSD) was used for pound-wise comparison when variance was homogeneous, and Games-Howell method was used when variance was uneven. Multiple stepwise regression method was used to analyze the influence of risk factors on the incidence of PDAP.

Findings of Data Analysis

Characteristics of Participants

The patients involved in this study were distributed in the south, central and northern Jiangsu Province, China, including 160 patients (40.82%) in the south (Nantong City), 134 patients (34.18%) in the north (Xuzhou City), and 98 patients (25.00%) in the central (Yancheng city). The basic information among the 392 PD patients, the average age was (49.74±12.52) years old, the youngest patients was 21 years old and the oldest one was 85 years old; and the average dialysis duration was (16.35±20.09) months, the shortest duration of dialysis was 1 month, the longest was 96 months; the average weight was (63.07±11.23) and the average body mass index(BMI) was (22.76±3.64). There were 234 male patients (59.69%) and 158 female patients (40.31%). 390 patients (99.49%) were Han nationality; There were 350 patients had married (89.29%), 22 unmarried (5.61%), 16 divorced (4.08%), and 4 bereaved (1.02%). 244 patients were unemployed (62.24%), 74(18.88%) were employed, 45(11.48%) were retired; 330 patients (84.18%) with annual income less than or equal to 50,000 yuan, 52(13.27%) between 50,000

to 150,000 yuan, and 10(2.55%) greater than or equal to 150,000 yuan; In terms of education level, 30 patients (7.65%) had primary school education, 176 (44.90%) had junior high school education, 140 participants (35.71%) had a senior high school or technical secondary school education level, and 46(11.73%) had junior college or undergraduate education. 224 patients (57.14%) were covered by worker's medical insurance, and 160(40.82%) were covered by rural medical insurance. 380 patients (96.94%) were non-smokers; 326 patients (83.16%) did not keep pets at home, 66 patients (16.84%) kept pets at home, mainly cats and dogs; 176 patients (44.90%) need to take less than or equal to 1 hour to PD center by car, 1-2 hours for 136 patients (34.69%), 2-3 hours for 44 patients (11.22%), and more than 3 hours for 36 patients (9.18%).

The medical factors among the 392 PD patients, the average serum calcium was (2.16±0.25mmol/L); serum phosphorus was (1.90±0.62mmol/L); serum potassium was (4.25+0.80mmol/L); serum albumin was (37.25±5.63g/L); iPTH : (668.42±539.16pg/ml); ALT was (20.62±11.88U/L); cholinesterase was (6665.72 ± 1267.64U/L); triglyceride was (2.03 ± 1.23mmol/L); creatinine was (675.69 ± 589.52umol/L); uric acid was (427.19 ± 120.19umol/L); hemoglobin was 106.00g/L (97.00g/L, 120.00g/L); CRP was 1.27mg/L (0.50mg/L, 5.34mg/L); alkaline phosphatase was 88.80U/L (73.70U/L, 126.60U/L); BUN was 22.13mg/dL (17.80mg/dL, 27.30mg/dL).

Dialysis-related factors among the 392 PD patients, 248 patients (63.27%) received continuous ambulatory peritoneal dialysis(CAPD), 118 patients (30.10%) received automatic peritoneal dialysis(APD), and 26 patients (6.63%) received intermittent peritoneal dialysis(IPD); 21 patients (5.36%) had 2 bags of dialysate/day, 47 patients (11.99%) had 3 bags of dialysate/ day, 233 patients (59.44%) had 4 bags of dialysate/day, 87 patients (22.19%) had 5 bags of dialysate/day, and 4 patients (1.02%) had 6 bags of dialysate/day; 368 patients (93.88%) performed PD by themselves; 24 patients (6.12%) were operated by family members or babysitters; a total of 322 patients (82.14%), underwent PD as their sole treatment modality, while 70 patients (17.86%), received HD in conjunction with PD. 232 patients (59.18%) received a Tenckhoff straight tube, 88 patients (22.45%) received a Swan-neck straight tube, and 72 patients (18.37%) received a Swan-neck coil tube; 322 patients (82.14%) were treated with peritoneal dialysis alone.

Among the 392 PD patients, 55 (14.03%) had complications of DM, 242 (61.73%) had CVD, 16 (4.08%) had CBVD, 12 (3.06%) had SHPT, 66 (16.84%) had anemia, 6 (1.53%) had SLE. 4 (1.02%) had pituitary tumors and 18 (4.59%) had gout. 6 (1.53%) had pulmonary infection, 7 (1.96%) had intestinal infection, 17 (4.34%) catheter and tunnel exit infection.

The score of SDS was (54.05 ± 11.85); score of SAS was (45.77 ± 8.91); score of CD-RISC was (69.31 ± 24.53); score of PSQI was (7.72 ± 3.99); score of MMSE was (26.95 ± 2.63).

Incidence of PDAP

The incidence of PDAP in the year from 1 Oct. 2023 to 31 Oct. 2024 was collected. Among the 392 followed up PD patients, 69 had PDAP, accounting for 17.60%. There were 120 occurrences of PDAP, 33 patients repeated occurrences, and the incidence of PDAP was 0.31 episodes/patient year.

Univariate Analysis Findings

Through univariate analysis, statistically significant variations were observed in the incidence of PDAP in serum potassium, serum albumin, ALT, triglyceride, dialysate bags/24hrs, total score Of MMSE, education background, PD patients with catheter and tunnel exit infection and DM ($P<0.05$), while others had no statistically significant differences in the incidence of PDAP. The specific results are shown in Table 1.

Table 1: Univariate Analysis Findings (N=392).

Variable	No PDAP (N=323)	PDAP (N=69)	t/Z/ χ^2	P
Age (Mean±SD)	49.42 ± 12.81	51.25 ± 11.06	t=-1.211	0.228
Weigh (Mean±SD)	63.00 ± 11.60	63.44 ± 9.38	t=-0.342	0.733
BMI (Mean±SD)	22.76 ± 3.84	22.74 ± 2.51	t=0.037	0.971
Dialysis duration (Mean±SD)	15.80 ± 19.52	18.94 ± 22.56	t=-1.074	0.286
Dialysate bags/24hrs	**3.94 ± 0.78**	**4.38 ± 0.64**	**t=-4.375**	**<.001**
Calcium (Mean±SD)	2.15 ± 0.24	2.18 ± 0.28	t=-0.728	0.467
Phosphorus (Mean±SD)	1.90 ± 0.62	1.91 ± 0.60	t=-0.144	0.885
Potassium (Mean±SD)	**4.34 ± 0.79**	**3.83 ± 0.69**	**t=5.001**	**<.001**
Albumin (Mean±SD)	**37.88 ± 5.41**	**34.30 ± 5.76**	**t=4.934**	**<.001**
iPTH (Mean±SD)	668.44 ± 534.83	668.27 ± 563.06	t=0.002	0.998
ALT (Mean±SD)	**21.13 ± 12.29**	**18.25 ± 9.39**	**t=2.175**	**0.032**
Cholinesterase (Mean±SD)	6656.36 ± 1275.65	6709.55 ± 1237.59	t=-0.316	0.752
Triglyceride (Mean±SD)	**1.93 ± 1.06**	**2.47 ± 1.78**	**t=-2.399**	**0.019**
Creatinine (Mean±SD)	683.71 ± 599.39	638.14 ± 543.43	t=0.621	0.536
SUA (Mean±SD)	432.31 ± 122.39	403.22 ± 106.83	t=1.831	0.068
BUN (Mean±SD)	22.82 ± 6.96	21.69 ± 6.39	t=1.237	0.217
SDS (Mean±SD)	54.45 ± 11.38	52.19 ± 13.76	t=1.272	0.207
SAS (Mean±SD)	46.03 ± 8.95	44.51 ± 8.69	t=1.289	0.198
CD-RISC (Mean±SD)	68.75 ± 24.29	71.93 ± 25.67	t=-0.976	0.330
PSQI (Mean±SD)	7.80 ± 4.01	7.36 ± 3.92	t=0.819	0.413
MMSE (Mean±SD)	**27.33 ± 2.43**	**25.17 ± 2.84**	**t=6.502**	**<.001**

Table 1: Univariate Analysis Findings (N=392).

Variable	No PDAP (N=323)	PDAP (N=69)	t/Z/ χ^2	P
Hb M (Q1, Q3)	106.00 (96.00, 120.00)	105.00 (98.00, 120.00)	Z=-0.094	0.925
CRP M (Q1, Q3)	1.28 (0.50, 5.34)	1.12 (0.50, 5.34)	Z=-0.043	0.965
Alkaline phosphatase M (Q1, Q3)	88.80 (73.80, 126.35)	93.20 (73.40, 132.40)	Z=-0.004	0.997
Gender, n (%)			χ^2=0.240	0.624
Male	191 (59.13)	43 (62.32)		
Female	132 (40.87)	26 (37.68)		
Nation, n (%)			-	1
Han	321 (99.38)	69 (100.00)		
Others	2 (0.62)	0 (0.00)		
Marital Status, n (%)			χ^2=3.682	0.298
Unmarried	21 (6.50)	1 (1.45)		
Married	285 (88.24)	65 (94.20)		
Divorced	13 (4.02)	3 (4.35)		
Bereaved	4 (1.24)	0 (0.00)		
Working Status, n (%)			χ^2=4.487	0.213
Unemployed	202 (62.54)	42 (60.87)		
Employed	64 (19.81)	10 (14.49)		
Retired	37 (11.46)	8 (11.59)		
Others	20 (6.19)	9 (13.04)		
Annual income, n (%)			χ^2=4.180	0.243
≤ RMB 50,000	272 (84.21)	58 (84.06)		
RMB 50,000 to 150,000	43 (13.31)	9 (13.04)		
RMB 150,000 to 300,000	6 (1.86)	0 (0.00)		
≥ RMB 300,000	2 (0.62)	2 (2.90)		
Education, n (%)			**χ^2=12.065**	**0.007**
Primary	29 (8.98)	1 (1.45)		
Junior high school	149 (46.13)	27 (39.13)		
High/Technical secondary school	114 (35.29)	26 (37.68)		
College/Undergraduate	31 (9.60)	15 (21.74)		
Medical Insurance, n (%)			χ^2=1.971	0.373
Rural medical insurance	133 (41.18)	27 (39.13)		
General Employee Medical Insurance	182 (56.35)	42 (60.87)		
Others	8 (2.48)	0 (0.00)		
Distance to PD center, n (%)			χ^2=3.717	0.294
≤1hr	147 (45.51)	29 (42.03)		
1-2hr	108 (33.44)	28 (40.58)		
2-3hr	40 (12.38)	4 (5.80)		
≥3hr	28 (8.67)	8 (11.59)		
Residence, n (%)			χ^2=0.590	0.745
Xuzhou	113 (34.98)	21 (30.43)		
Nantong	131 (40.56)	29 (42.03)		
Yancheng	79 (24.46)	19 (27.54)		
Smoking, n (%)			χ^2=0.007	0.931
Yes	10 (3.10)	2 (2.90)		
No	313 (96.90)	67 (97.10)		
Keeping pets, n (%)			χ^2=0.240	0.624
Yes	53 (16.41)	13 (18.84)		
No	270 (83.59)	56 (81.16)		
Method of Dialysis, n (%)			χ^2=0.424	0.809
APD	99(30.65)	19(27.54)		
CAPD	202(62.54)	46(66.67)		
IPD	22(6.81)	4(5.80)		
Dialysis Unit (Type of Tube), n (%)			χ^2=1.248	0.536
Tenckhoff straight tube	194 (60.06)	38 (55.07)		
Swan-neck straight tube	69 (21.36)	19 (27.54)		
Swan-neck coil tube	60 (18.58)	12 (17.39)		
Operator, n (%)			χ^2=3.283	0.070
Patient	307 (95.05)	61 (88.41)		
Others	16 (4.95)	8 (11.59)		
Treatment, n (%)			χ^2=0.860	0.354
Yes	55 (17.03)	15 (21.74)		
No	268 (82.97)	54 (78.26)		
Pulmonary Infection, n (%)			χ^2=0.004	0.952
Yes	5 (1.55)	1 (1.45)		
No	318 (98.45)	68 (98.55)		
Intestinal Infection, n (%)			χ^2=3.134	0.077
Yes	4 (1.24)	3 (4.35)		

Table 1: Univariate Analysis Findings (N=392).

Variable	No PDAP (N=323)	PDAP (N=69)	t/Z/ χ^2	P
No	319 (98.76)	66 (95.65)		
Catheter and Tunnel Exit Infection, n (%)			**χ^2=61.128**	**<.001**
Yes	2 (0.62)	15 (21.74)		
No	321 (99.38)	54 (78.26)		
DM, n (%)			**χ^2=15.527**	**<.001**
Yes	35 (10.84)	20 (28.99)		
No	288 (89.16)	49 (71.01)		
CVD, n (%)			χ^2=3.053	0.081
Yes	193 (59.75)	49 (71.01)		
No	130 (40.25)	20 (28.99)		
CBVD, n (%)			χ^2=0.629	0.428
Yes	12 (3.72)	4 (5.80)		
No	311 (96.28)	65 (94.20)		
SLE, n (%)			-	1
Yes	5 (1.55)	1 (1.45)		
No	318 (98.45)	68 (98.55)		
SHPT, n (%)			-	0.701
Yes	11 (3.41)	1 (1.45)		
No	312 (96.59)	68 (98.55)		
Pituitary tumors, n (%)			-	0.541
Yes	3 (0.93)	1 (1.45)		

Note.
"t" means t test; "Z" means Mann-Whitney U test; "χ^2" means Chi-square test; "—" means Fisher accuracy test.

Logistic Regression Analysis Findings

PDAP occurrence served as the dependent variable, while 9 variables significant in univariate analysis were used as independent variables to screen for factors using a two-way approach. The results were shown in Table 2.

Table 2: Logistic Regression Analysis Findings (N=392).

Risk Factors	Regression Coefficient	Standard Error	Wald	Freedom Degrees	P	OR	95%CI
Serum Potassium	-0.909	0.265	11.777	1	<.001	0.403	0.240-0.677
Serum Albumin	-0.114	0.035	10.442	1	0.001	0.892	0.833-0.956
Triglyceride	0.577	0.139	17.259	1	<.001	1.780	1.356-2.337
Catheter and Tunnel Exit Infection	4.131	1.052	15.413	1	<.001	62.267	7.916-489.787
DM	1.212	0.460	6.932	1	0.008	3.360	1.363-8.282
MMSE	-0.305	0.075	16.705	1	<.001	0.737	0.637-0.853
Constant	9.071	2.868	10.001	1	0.002	8696.657	

Discussion

Analysis of PDAP

PD is a long-term treatment, which is mostly done at home by patients themselves or their caregivers, and the control of the process by medical staff is relatively poor. PDAP is the most frequent infectious complication among patients undergoing PD, leading to alterations in peritoneal structure and function, increase hospitalization frequency and treatment cost, and reduce patients' quality of life.[24] However, due to the comprehensive influence of geographical location, climatic conditions, medical level and people's lifestyle, the incidence of PDAP has a certain difference in the world. In this study, 392 patients with PD who came to the hospital for regular follow-up in the southern, northern and central Jiangsu Province were selected for investigation. The occurrence rate of PDAP was 0.31 episodes/patient·year. This is similar to the global average incidence of peritonitis reported in the literature of 0.3 episodes/patient·year,[7] but much higher than the 0.175-0.198 episodes/patient·year reported in China.[8]

Investigation into the Risk Factors for PDAP

The study revealed that multiple factors influenced the development of PDAP was affected by serum albumin, serum potassium, triglyceride, total score of MMSE, PD patients with catheter and tunnel exit infection and DM. The analysis confirmed that serum albumin serves as an independent risk factor for PDAP and exhibits a negative correlation with its occurrence, aligning with findings from earlier research.[25] Patients with ESRD often show protein energy wasting (PEW), which is closely related to a high fatality rate.[26] Low protein levels can impair peritoneal defense mechanisms, elevating the risk of infection. During inflammatory states, albumin production is further diminished. Therefore, this risk factor should be detected early and appropriate nutritional intervention should be carried out to alleviate and prevent the occurrence of peritonitis.

This study showed that blood potassium was also negatively correlated with the occurrence of PDAP, which was consistent with the findings of Davies *et al.*[25] and Yu *et al.*[27], Hypokalemia was even an independent predictor

of death in PD patients.[28] A randomized, controlled trial (RCT) by Pichitporn *et al*.[29] showed the effectiveness of potassium supplementation in the prevention of PDAP. Therefore, medical staff should teach patients to recognize the signs and symptoms of hypokalemia in time and seek medical attention in time.

This study shows that: triglycerides are considered a potential risk factor for PDAP, although no current studies have definitively confirmed this link. Nevertheless, triglycerides are the most prevalent lipid metabolism abnormality in CKD patients and are strongly associated with an increased risk of cardiovascular disease. Hypertriglyceridemia is an independent risk factor for treatment failure in patients with PDAP.[30] In this study, 59.75% of PD patients with complicated by cardiovascular disease. Therefore, further research is required to explore the impact of abnormal triglyceride levels on PDAP development.

The results showed that the score of MMSE was an independent predictor for the incidence of PDAP, PD patient's average score of MMSE was (26.95 ± 2.63), which belonged to mild cognitive impairment (MCI). Consistent with previous research,[16,31,32] MCI can increase the risk of hospitalization, technical failure, peritonitis, and mortality.[33, 34] MMSE is a mature tool for screening cognitive function in patients with CKD,[35] and cognitive impairment has been shown to be an independent predictor of mortality and dialysis discontinuation[36] in dialysis patients.[37] In a large-scale multi-center cohort study of PD patients in China, the prevalence of cognitive impairment diagnosed with MMSE was less than 23.6%.[37]

The study indicated that catheter and tunnel exit infection is independent risk factors for PDAP, which is consistent with the results of previous studies of AlZabli *et al*.[38], Au *et al*.[39] and Soetendorp *et al*.[40]. Catheter and tunnel exit infection increases the risk of PDAP because microorganisms are transferred from the outlet site to the peritoneal cavity through the peritoneal catheter,[39] especially PDAP caused by staphylococcus aureus or pseudomonas aeruginosa, these infections are often refractory or recurrent. According to statistics, 20% of all PDAP patients are the first to develop exit or tunnel infection. Catheter and tunnel exit infection is a risk factor for PD catheter removal, and the main reason for catheter loss induced by catheter and tunnel exit infection is refractory catheter and tunnel exit infection or concomitant peritonitis.[38]

This study showed that PD patients with diabetes increased the incidence of PDAP, which was consistent with the findings of Zhang *et al*.[41] and Tang *et al*.[42]. Diabetes is one of the common causes of kidney failure and an important reason for increasing the risk of infection in patients, which may be related to the impaired immune function and peritoneal defense function in patients with diabetes.[43] In addition, some PD patients with diabetes and diabetic retinopathy may also cause peritonitis due to improper operation. Therefore, for patients with PD complicated with diabetes, relevant operation training should be strengthened, the quality of patient aseptic technology training should be improved, and multiple follow-up systems should be optimized.

This study revealed that cognitive function in PD patients influences the risk of PDAP. Shea *et al*.[34] found that PD patients with cognitive impairment had an increased likelihood of developing PDAP within a year. However, the study results of Brás *et al*.[44] showed that patients with PD accompanied by mild cognitive impairment had a greater risk of PDAP.

Conclusions

In conclusion, we reported the effects of serum albumin, serum potassium, triglyceride, total score of MMSE, PD patients with catheter and tunnel exit infection and DM on the occurrence of PDAP. However, the effects of triglyceride on the occurrence of PDAP need to be further discussed.

Suggestions

The ability of medical staff to identify the risk factors of PDAP should be improved: 1. Nursing managers should enhance the capacity of medical staff to recognize PDAP by providing standardized prevention training; 2. Strengthen the improvement of patients' health education and self-management ability. In addition to traditional health education methods such as regular patient follow-up to the hospital and distribution of publicity materials, the online media mode of "Internet + nursing" can also be used to popularize the relevant knowledge of PDAP prevention for patients. The contents can be formulated according to the causes and risk factors of PDAP, including strict aseptic operation, rational diet, drinking water plan, rational drug use, etc. 3. Building a clinical prediction models for PDAP, identify high-risk patients through the model, and implement hierarchical management of patients, which on the one hand can improve the efficiency of patient management and optimize clinical medical and nursing human resources.

Limitations

The limitation of this research is that it is difficult to take into account all the factors affecting the incidence of PDAP in a single study. Of the many factors that influence the occurrence of PDAP, only 6 were considered by referring to their importance and then conducting an in-depth literature review. The next challenge is the multi-dimensionality of each exogenous variable considered in the current study. Here, again, a selection from the different dimensions of each important structure is examined. It turns out that the total variances described by some important variables are small. Therefore, it is recommended that future studies include other important variables, such as genomics-related factors, and take the dimensions of each variable already considered.

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Authors' Contributions

Sairah Abdul Karim designed, guided and supervised the development and quality of the project; Guo Lingling project design, data gathering, statistical analysis, and authorship of the paper. Qian Hailan, Shen YuanYuan, Qian WeiWei, Liu Yin, Xu Min, Li Na participated in the data collection. All authors read the paper and agreed with the final content.

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Data and Material Accessibility

All data collected or evaluated throughout this research are encapsulated within the present document. For additional information, please contact the corresponding author.

Declarations

Ethical Considerations and Participation Agreement

Adhering to the principles outlined in the Declaration of Helsinki, this investigation was sanctioned by the Ethics Committee at Yancheng Third People's Hospital. Each participant provided written consent for their involvement.

Publication Approval

Not relevant.

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The authors affirm that they have no conflicts of interest to disclose.

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