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Prevalence of Peritonitis in Continuous Ambulatory Peritoneal Dialysis Patients: Bacteriology Analysis

Conflict of interest: nothing to declare.
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Abstract

Introduction. Peritoneal dialysis (PD) linked with peritonitis is a major risk factor for patients with continuous ambulatory Peritoneal dialysis (CAPD). Factors affecting biochemical characteristics and microbiological data pertinent to PD-related peritonitis (PDRP) are deficient in the Iraq studies. Thus, an observational assessment of patients with CAPD is required to look for susceptible organisms that cause peritonitis and biochemical characteristics outcome.

Materials and methods. Blood and peritoneal fluid samples were collected from 100 patients with end-stage chronic kidney disease who underwent CAPD. Different biochemical parameters and microbiological assays of CAPD fluid were analyzed at the laboratory level such as complete blood count (CBC), calcium, phosphate, parathyroid hormone, potassium, sodium, and more factors were included in the current study.

Results. A total of 100 CAPD patients, 62 of whom developed at least one attack during the study period. Those developed a total of 301 episodes of peritonitis. The overall peritonitis rate was 3.1 episodes/patient-year. The causative pathogens are gram-positive (Staphylococcus aureus and Enterococcus sp.) and gram-negative bacteria (Escherichia coli and Klebsiella sp.). The study revealed that patients developing peritonitis with CAPD have diverse biochemical characteristics.

Conclusion. This study showed that peritonitis offers insights into the etiology and outcomes of infectious complications of PD at Basrah Teaching Hospital, nephrology, and dialysis center in Basrah. Thus, critical information was concluded from the study to better manage peritonitis with CAPD and early decision-making.

Keywords: CAPD, Diabetes, Peritonitis, Infection, renal replacement therapy

INTRODUCTION

For patients with end-stage renal disease, renal replacement therapies (RRT) such as dialysis and kidney transplantation represent the sole treatment options to sustain life [1]. Kidney transplantation is a potential and efficient cure, although kidney transplantation surgery is limited by factors such as high-cost surgery, shortage of donors, and transplant failure. Hence patients depend on dialysis for long-term or even life-long.

Worldwide, continuous ambulatory peritoneal dialysis (CAPD) has been accepted as an alternative to RRT which can be even executed at home with proper training. Often peritonitis appears as a serious issue of peritoneal dialysis that causes extension in hospital care, despondency, and even death among CAPD patients [2]. Peritonitis may be caused due to catheter loss and technical failure of the instruments engaged to manage peritonitis [3].

Literature reveals that there are several different forms of microorganisms accountable for the result of peritonitis occurrence such as Staphylococcus epidermidis, Escherichia col i, Klebsiella species, Proteus species, Enterococcus faecalis, Pseudomonas species, Serratia sp. and Corynebacteria [4]. Peritonitis also depends on various factors like geographical conditions, socio-demographic parameters, and conditional immunity of peritonitis patients [5]. The infection is caused by gram-positive as well as negative bacteria, fungi, and in some cases viruses also an infectious agent. Microbes are inhabitant in the peritoneal fluid at the time of infection and play a crucial role in the results of the varying types of dialysis mode, this state of affairs remains an incumbency among continuous ambulatory peritoneal dialysis patients [3, 5].

Differences in peritonitis occurrence worldwide have resulted in several flexible parameters in which medical practice patterns are also accountable factors [1]. A report on Peritoneal Dialysis Outcomes and Practice Patterns Study (PDOPPS), seven countries viz. Canada, Japan, Australia, New Zealand, Thailand, the UK, and the USA were selected in around 7000 patients across the selected nations subjected to Peritoneal Dialysis have different peritonitis rates [2]. Medical procedures such as higher application of automated peritonitis dialysis (APD), inclusion of antibiotics before and after catheter introduction, and descriptive training of peritonitis liquid exchange are key factors that lower the infection. In several countries, peritonitis results mostly from gram-positive bacteria. A study in 2011, in Australia and New Zealand showed that gram-positive bacteria account for nearly 53% of total peritonitis dominated by Staphylococci (27.2%) and Escherichia coli (6.3%) and at par, USA, Canada, and India also have dominant gram-positive bacterial infection resulted for peritonitis [6].

Peritonitis connected with PD, microbial infection as well, and consequences have not been yet defined for the CAPD patient population being medicinally treated at Basrah teaching hospital, nephrology, and dialysis center in Basrah. This is a reflective assessment aimed at investigating the local peritonitis rate, the microbiological profiles of causative organisms along with biochemical characteristics associated with peritonitis to draw management protocols.

MATERIALS AND METHODS

Study design

The study was conducted from March 2019 to March 2024. The samples were collected from the nephrology and dialysis center in Basrah Teaching Hospital. The study

was approved by scientific committees in the College of Medicine, University of Basrah (No.030408-031-2023). Written informed consent was obtained from all the patients who participated in the study.

Samples collection

5 mL of the venous blood sample was drawn from each patient by using disposable syringes in plain tubes without any anticoagulant. Samples were processed immediately which involved the separation of blood serum by centrifuge at 10000 rpm for 5 min at 4° C. The collected samples were also subjected to the biochemical quantitative assessment for urea, blood gases analysis, complete blood count, calcium, phosphate, Parathyroid hormone, potassium, sodium, and bicarbonate.

Peritoneal fluid white blood cell (WBC) and Culture and sensitivity

We collected a sample of peritoneal fluid and sent it for WBC count and WBC differential with culture and sensitivity for all studied patients.

Statistical analysis

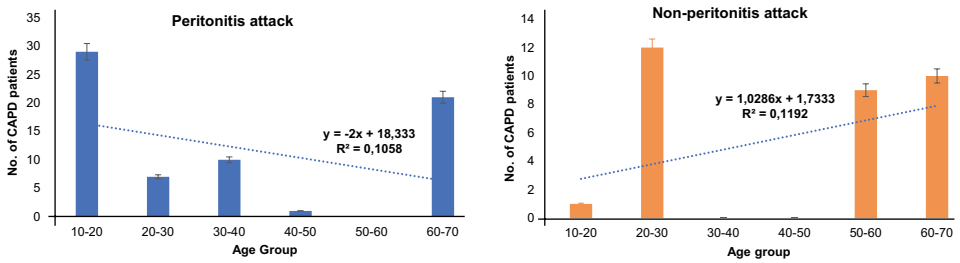
The statistical analysis was performed using SPSS software version 20. Calculations of mean values and standard deviation (SD) were made for the characterization of the study population. The statistical significance of the difference in data was assessed by the T-test. P values <0.05 were considered to be statistically significant.

■ RESULTS

Demographic and clinical characteristics of the study population

In the current investigation, one hundred patients (mean age 36.6 years; 60% males, 40% females) per year were examined and the mean duration of peritonitis dialysis treatment was 4.42 per year and the overall peritonitis rate was 3.1 episodes/patient/year. The patients developed 301 episodes of peritonitis (range: 1–6 episodes per patient) of which 32% were non-reverting peritonitis and 68% were recurring peritonitis (Fig.1). The majority of the patients were males (72.06 %) between 10–20 years (specifically 11–13 years age group) followed by post 60 years of male (42.46%) while the maximum female age had peritonitis at the age of 22 years (36.86%) and 34 years (52.63%). The male peritonitis-affected patients were higher accounted for 49%, while female peritonitis-affected affected were reported 19% of the examined population. The peaked age was 66 years and least age was 11 years (Fig. 1).

Only 31 male patients had cardiovascular morbidities, and no malignancies, and 4 females suffered from the genetic disease Thalassemia (Fig. 2). No female reported multiple complications, whereas 60% of males had multiple complications of diabetic mellitus, hypertension, and ischemic heart disease (Fig. 2). The overall morbidity rate was 68% in the current study. The majority of the examined population had diabetic mellitus at a rate of 52% (Males: Females = 31%: 21%). Among the other morbidities, hypertension was second in occurrence with 41%; whereas ischemic heart disease and one genetic disease such as Thalassemia were 31% and 4% respectively. Besides diabetes, other co-morbidity such as hypertension and ischemic heart disease were restricted only to male patients.



A B

Fig. 1. Demographical distribution pattern of peritonitis (A) and non-peritonitis patients (B)

The data showed that 31% of patients were under treatment of continuous ambulatory peritoneal dialysis (CAPD) for more than one year while 69% of the examined population were under CAPD for less than one year. The devices implanted for CAPD in the patients were manufactured by Fresenius (52%) and Baxter (48%). The CAPD catheter was inserted in the body either by surgery or by medical method. The surgical procedure was adopted in 79% of critical patients while 21% were subjected to medical methods. Peritoneal Equilibration Test (PET) revealed that the patient's peritoneum has a high, average, or low transport rate and the test resulted in relevant information on peritoneum drain volume. The PET selected as the test reflects how much dextrose remains in the fluid sample, and how much 4-hour dialysate/plasma creatinine. The PET result showed that 1% of the population had a low transport rate, 30% of patients of the population required a high transport rate, and 69% of patients required average transport for fluid exchange.

Causative Organisms of Peritonitis

The distribution of pathogenic bacteria in the population was mainly Escherichia coli (15), Enterococcus species (12), Staphylococcus aureus (14), and Klebsiella sp. (10).

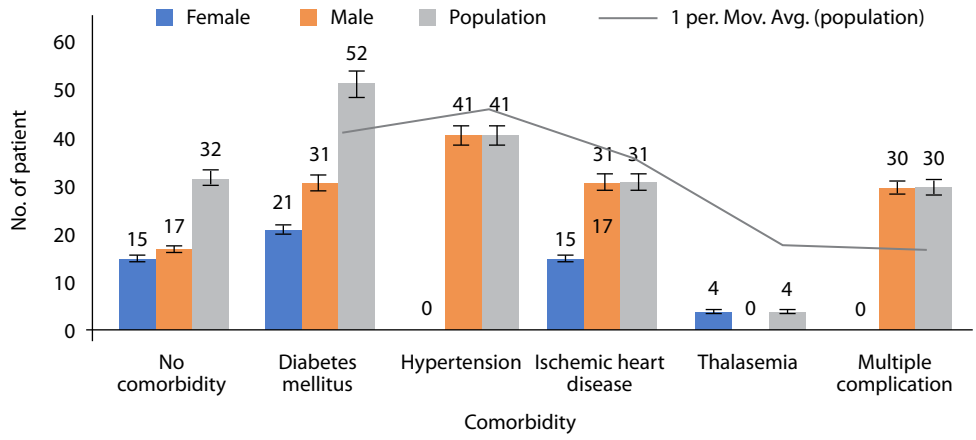


Fig. 2. Distribution pattern of Co-morbidity in the examined population

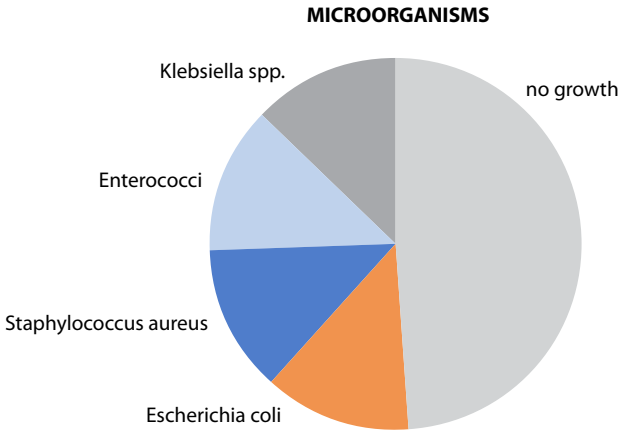


Fig. 3. Pathological agents accountable for the prevalence of peritonitis

Most dominant bacterial infection that resulted in peritonitis was Escherichia coli with 29% of occurrence among bacterial infection followed by 27% of Staphylococcus aureus (27%) and Enterococcus species (24%) infection (Fig. 3). The least abundance pathogenic bacteria that were noticed and responsible for peritonitis was Klebsiella sp. with 20% presence. The result exhibited that the causative pathogenic peritonitis in the population was equally infected by gram-positive (Staphylococcus aureus and Enterococcus sp.; 51%) and gram-negative bacteria (Escherichia coli and Klebsiella sp.; 49%).

Biochemical characteristics of the examined population

The serum of all examined patients was collected and processed for details assessment at the biochemical level. The biochemical analysis comprised of determination of hemoglobin (Hb) count, Albumin, Uric acid, Potassium, Sugar, Sodium, C Reactive protein (CRP), Ferrintin, Parathyroid hormone test, Calcium, Phosphate test, and Vitamin D. The mean Hb was 8.72 g/dl with a range of 5–11 g/dl. The female population had slightly elevated Hb near 8.9 mg/dl while the male had 8.4 mg/dl. The mean WBC count of the examined population was 12.49×10^3/dl and in the range of $3.5–30\times10^3$/dl. The male WBC count (10.9×10^3/dl) is comparatively lower than the female (14.9×10^3/dl).

The mean albumin was 3.07 gm/dl and the range of albumin presence was 2–3.6 gm/dl. The uric acid among the examined population was 4–7.7 mg/dl and the mean occurrence of uric acid in the population was 6.23 mg/dl. The mean male and female uric acid presence was 5.9 mg/dl and 6.7 mg/dl respectively. Higher mean potassium was found in the urine sample of males (3.8 meq/l) compared to females (3.1 meq/l). The mean cumulative potassium was determined within 3.55 meq/l and the normal range in the examined population was 2.2–5.5 meq/l.

The sugar range within the population was 88–400 mg/l with a mean value of 170 mg/l. However, the average serum sugar (149.7 mg/l) of men was near to threshold or safe limit while the females (202.5 mg/l) had 26.4% higher sugar than males. The mean serum sodium, phosphate, and vitamin D were found to be 147.3 meq/l, 5.9 mg/dl,

Table 1
Mean biochemical characteristics of female and male population under the influence of Peritonitis

Biochemical characteristics	Female		Male	
	Peritonitis attack	Non-peritonitis attack	Peritonitis attack	Non-peritonitis attack
Hb	8.7	9.0	8.7	8.3
WBCs	19.8	10.5	11.2	9.5
Albumin	2.8	3.3	3.0	3.3
Uric Acid	6.9	6.6	5.9	6.0
Potassium	2.7	3.5	3.7	4.6
Sugar	226.7	180.6	142.7	180.9
Sodium	128.9	135.4	151.4	129.0
C Reactive protein	14.7	8.1	8.5	11.0
Ferritin	247.4	220.0	114.7	146.5
PTH	278.9	222.9	406.7	552.0
Calcium	6.6	8.0	7.0	7.8
Phosphate	6.6	5.4	5.8	5.8
Vitamin D	17.6	19.7	12.2	16.2
Chi-Square test P<0.05%	0.652 (NS*)		0.278(NS*)	
T-Test (p<0.05%)	0.801 (NS*)		0.751 (NS*)	

and 13 ng/ml in males whereas 132.4 meq/l, 6 mg/dl, 18.7 ng/ml in females respectively. The mean serum calcium was between 7.2–7.3 mg/dl in the population. The mean calcium distribution in the population was 7.24 mg/dl and at par in males and females with a normal range of 5–9 mg/dl (Table 2).

Table 2
Mean biochemical characteristics of investigatory population irrespective of Peritonitis attack

Biochemical characteristics	Female	Male	Cumulative
Hb	8.9	8.6	8.72
WBCs	14.9	10.9	12.49
Albumin	3.0	3.1	3.074
Uric Acid	6.7	5.9	6.227
Potassium	3.1	3.8	3.556
Sugar	202.5	149.7	170.8
Sodium	132.4	147.3	141.31
C Reactive protein	11.3	9.0	9.9
Ferritin	233.0	120.5	165.5
PTH	249.5	433.3	359.78
Calcium	7.3	7.2	7.24
Phosphate	6.0	5.8	5.9
Vitamin D	18.7	13.0	15.27
Chi-square test P<0.05%	0.0001 (S)		NA
T-Test (p<0.05%)	0.982, (NS*)		NA

Notes: NS* – Non Significant; NA – Not applicable, S – Significant.

The mean Ferritin and Parathyroid Hormone (PTH) in the testing population were estimated and recorded between the range of 23–400 ng/ml and 80–797 pg/ml, respectively. The mean Ferritin in the female examined population (233 ng/ml) was a 48.28% increase compared with the male-examined population. The PTH was 42.41% elevated in the male population which resulted in 433.3 pg/ml while in mean PTH in the female population was 249.5 pg/ml. The C reactive protein (CRP) in the examined population was measured between 2–30 mg/l with the mean value mean CRP 9.9 mg/l. The elevated CRP above 10 mg/l indicates inflammation in the body. The female population (11.3 mg/l) had 20.90% higher CRP than the male (9 mg/l) population. It has been confirmed by the chi-square test at a significant level (0.05%), $p<0.0001$ those overall biochemical characteristics of males and females strongly related to suffering from common peritonitis infection (Table 1). The t-test performed in the population was non-significant (0.05%, $p=0.982$) and showed that the two groups are different from one another in respect of biochemical characteristics (Table 2).

The biochemical characteristics of peritonitis attack patients and non-peritonitis attack patients within the male and female groups were examined. The chi-square and t-test were performed which resulted in acceptance of the null hypothesis by exhibiting non-significant results ($p<0.05\%$) that interpret that within the given gender under two different medical conditions, the biochemical characteristics are different in the examined population. The Person's correlation coefficient of biochemical characteristics was among the females having Peritonitis and non-peritonitis attack (Table 3), male Peritonitis and non-peritonitis attack (Table 4), and Overall, between males and females irrespective of peritonitis attack (Table 5). Several biochemical characteristics showed positive and negative correlation coefficients.

Table 3
Pearson's correlation coefficient (R^2) of biochemical characteristics between peritonitis-affected and non-peritonitis-affected female patients under investigation

	Hb	WBCs	Albumin	Uric Acid	Potassium	Sugar	Sodium	C Reactive protein	Ferritin	PTH	Calcium	Phosphate	Vitamin D
Hb	1.00												
WBCs	–0.83	1.00											
Albumin	0.79	–0.95	1.00										
Uric Acid	0.31	0.15	–0.28	1.00									
Potassium	–0.49	–0.03	0.02	–0.56	1.00								
Sugar	–0.56	0.75	–0.85	0.55	0.10	1.00							
Sodium	0.67	–0.90	0.98	–0.44	0.10	–0.90	1.00						
C Reactive protein	–0.79	0.93	–0.89	0.25	0.16	0.88	–0.87	1.00					
Ferritin	–0.99	0.80	–0.75	–0.39	0.45	0.46	–0.63	0.71	1.00				
PTH	0.33	0.15	–0.27	0.97	–0.56	0.57	–0.43	0.26	–0.42	1.00			
Calcium	0.07	–0.58	0.61	–0.85	0.55	–0.74	0.71	–0.62	0.02	–0.88	1.00		
Phosphate	–0.66	0.94	–0.94	0.44	–0.14	0.89	–0.94	0.95	0.59	0.45	–0.79	1.00	
Vitamin D	0.77	–0.85	0.96	–0.27	–0.12	–0.88	0.96	–0.83	–0.73	–0.26	0.52	–0.85	1

Table 4
Pearson's correlation coefficient (R^2) of biochemical characteristics between Peritonitis and non-peritonitis Male patients under investigation

	Hb	WBCs	Albumin	Uric Acid	Potassium	Sugar	Sodium	C Reactive protein	Ferritin	PTH	Calcium	Phosphate	Vitamin D
Hb	1.00												
WBCs	–0.26	1.00											
Albumin	–0.48	–0.30	1.00										
Uric Acid	0.86	–0.05	–0.35	1.00									
Potassium	–0.09	0.30	0.40	0.38	1.00								
Sugar	–0.07	0.44	0.18	0.42	0.89	1.00							
Sodium	–0.60	0.25	–0.17	–0.61	–0.46	–0.17	1.00						
C Reactive protein	0.03	0.75	–0.09	0.44	0.81	0.85	–0.24	1.00					
Ferritin	0.59	0.28	–0.17	0.88	0.64	0.75	–0.53	0.74	1.00				
PTH	–0.29	–0.55	0.36	–0.35	–0.23	–0.08	0.31	–0.55	–0.32	1.00			
Calcium	0.44	–0.66	0.46	0.35	0.21	–0.14	–0.82	–0.21	0.14	–0.05	1.00		
Phosphate	0.11	0.60	–0.14	0.53	0.63	0.77	–0.01	0.85	0.72	–0.53	–0.25	1.00	
Vitamin D	0.23	–0.86	0.60	0.22	0.16	0.00	–0.44	–0.38	0.06	0.48	0.78	–0.26	1.00

Table 5
Pearson's correlation coefficient (R^2) of biochemical characteristics between Peritonitis affected and non-peritonitis investigatory population

	Hb	WBCs	Albumin	Uric Acid	Potassium	Sugar	Sodium	C Reactive protein	Ferritin	PTH	Calcium	Phosphate	Vitamin D
Hb	1.00												
WBCs	–0.63	1.00											
Albumin	0.43	–0.81	1.00										
Uric Acid	0.53	0.11	–0.23	1.00									
Potassium	–0.23	–0.03	0.19	0.10	1.00								
Sugar	–0.39	0.72	–0.62	0.37	0.24	1.00							
Sodium	–0.25	–0.11	0.08	–0.64	–0.26	–0.27	1.00						
C Reactive protein	–0.42	0.79	–0.57	0.37	0.49	0.81	–0.29	1.00					
Ferritin	–0.35	0.67	–0.54	0.54	0.27	0.58	–0.46	0.69	1.00				
PTH	–0.10	–0.27	0.12	–0.37	–0.06	–0.03	0.35	–0.35	–0.42	1.00			
Calcium	0.23	–0.50	0.51	0.15	0.25	–0.43	–0.55	–0.38	0.10	–0.20	1.00		
Phosphate	–0.29	0.72	–0.58	0.46	0.34	0.75	–0.12	0.89	0.61	–0.31	–0.46	1.00	
Vitamin D	0.46	–0.46	0.60	0.28	–0.16	–0.25	–0.31	–0.42	–0.02	0.00	0.60	–0.38	1.00

■ DISCUSSIONS

Peritoneal dialysis patients most frequently experience procedure failure and morbidity due to peritonitis. To use the local empirical antibiotic treatment, the International Society of Peritoneal Dialysis (ISPD) advises each center to track the rates of peritonitis and the etiological agent [7]. Previous research has found that the risk of peritonitis is comparable across age groups, including advanced age [8, 9], greater BMI, and lower blood albumin levels [10]. Age as a risk factor for peritonitis may be explained by physical and cognitive deficits such as admonished dexterity and vision, hand tremors, and dementia in elderly patients, which might make the procedure difficult to execute [11]. Earlier studies showed higher BMI was related to an increased risk of early-onset peritonitis [12]. Obesity was thought to increase the risk of peritonitis during PD catheter implantation.

As compared to our findings, an Indian-based study reported rates of gram-positive culture varied between 30–72% [13, 14] and gram-negative bacteria were accountable for 60–66% of the peritonitis infection, while E. coli is the most common pathogen [14, 15]. A study conducted by Prasad et al. (2004) reported the occurrence of fungal peritonitis with an infection rate of 13.5% in it examined population, however, no such observation was reported in the current investigation in the examined population [16].

In the present study, the overall morbidity rate was 31 % and the results correspond to the studies conducted by Jhobta et al. (2006) reported a morbidity rate of 50%, whereas Memon et al. (2012) mentioned morbidity 48.5% in their investigation. The co-morbidity was higher in the male population with multiple complications such as hypertension, diabetes, and ischemic heart disease [17, 18]. Paryani et al. (2013) acknowledged that important parameters such parameters that have an important effect on mortality are heart rate, blood pressure, and relatively high blood sugar [19].

The comparatively lower Hb concerning the normal range in the examined population was recorded. Kunin et al (2023) reported that WBC increased during the peritonitis infection and similar results of observed in the current examined population [20]. Ascites, a pathological accumulation of fluid in the peritoneal cavity may come with several diseases. Serum ascites albumin gradient (SAAG) is calculated as the difference between the albumin level of serum and ascitic fluid and albumin that should be less than 6 gm/dl fluid. However, our result indicates a safe level of albumin in the population, and albumin was at par in females and males. The elevated SAAG indicates portal hypertension while a lower dose indicates the absence of portal hypertension [21].

In the current scenario, the safe range of uric acid in the serum is accepted as 3–7 mg/dl and our results corroborate with the other findings. The interpreted data related to the sugar level of examined patients were higher and observed that females were more diabetic than male patients. However, a study by van Diepen et al., (2015) confirmed there no correlation between glucose exposure during the first year of PD and the subsequent time to peritonitis had been noticed [22]. The critical serum potassium and sodium levels were 4.47±0.35 mEq/L and 142.67±2.64 mEq/L, respectively [23]. Mokhber Dezfouli et al. (2012) reported that peritonitis causes a reduction in Na ions because of the inflammation process. The K and Na were observed in a safe range in the examined population which corresponds with the result of Nakai et al (2017) [24, 25].

The C-reactive protein (CRP) frequently gets elevated within a short period of hours after the tissue is exposed to injury or due to the presence of microbial infection [26]. In a healthy body, CRP is normally available at less than 6 mg/l [27]. Elevated CRP has

been marked as an indicator of inflammation in a patient with infections or injuries [28]. Elevated CRP was reported due to the cause of Escherichia coli, Proteus spp., Klebsiella pneumoniae, Staphylococcus aureus, and others [29]. The CRP in the female population was 52.16% increased than the normal range while male patients had 71% higher than the normal value. The commutatively CRP in the population was higher by 66.66% (9.9 mg/l) and it was inferred from the that the examine population had severe tissue inflammations of patients.

Serum ferritin reflects total body iron stores; thus, a low serum ferritin is used as a parameter of iron deficiency. Clinically, higher ferritin level was pointedly linked with an additional rapid residual renal function decline in patients undergone PD [30]. The data of the current study revealed that females had normal levels of ferritin but exceptionally lower in males. Patients with high iron status were positively linked with the treatment failure of peritonitis [31].

Abnormal mineral bone metabolism in PD patients with low serum parathyroid hormone levels, coupled with either high Ca levels or low/normal P levels, could be new potential risk factors of PD pertinent to peritonitis [32]. In the blood, the delicate process of calcium and phosphate homeostasis is regulated firstly by the parathyroid gland. The gland secretes parathyroid hormone (PTH) when low calcium concentration is detected in the blood as the hormones assist in the manufacturing of Vitamin-D and calcitriol in the kidney. Further, PTH coupled with calcitriol controls calcium and phosphate in bones, kidneys, and small intestines [33]. Further, biochemical parameters within the population showed significant differences, however comparison of non-peritonitis and peritonitis patients showed non-significant differences.

■ CONCLUSIONS

The study has a rather low peritonitis rate, elderly individuals had a higher risk of peritonitis episodes. Gram-positive and gram-negative bacteria were the most common causes of peritonitis in CAPD patients. In conclusion, the investigation revealed a wide range of information pertinent to PD patients with CAPD. The biochemical features revealed a broad range of variability among the investigated group.

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