Original Research Article

IMPACT OF BACTERIAL INFECTIONS IN PERITONEAL DIALYSIS PATIENTS

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Abstract: *Bacterial infections can cause significant clinical complications in patients undergoing Peritoneal Dialysis (PD). This study aimed to determine bacterial infection's clinical and psychosocial outcomes in PD patients. A prospective observational study enrolled 150 PD patients through non-probability sequential sampling. Demographic information, duration of PD, previous infections, and laboratory results were collected. Bacterial infections were identified through routine cultures of PD fluids, and antibiotic susceptibility was determined using the disc diffusion method. The average age of PD patients was 52.3 years, with 42% men and 58% women (p<0.05). Staphylococcus aureus infected 22 patients (14.67%), whereas Streptococci infected 18 patients (12%) (p<0.05). Antibiotic susceptibility assays determined that Staphylococcus aureus was 77% sensitive to vancomycin. Seventy-five patients (50%) on PD for more than 19 months encountered infections. Among the infected group, 90 patients (60%) recovered without complications, while 5 (4.2%) died. The study revealed a significant correlation between bacterial infections in PD patients and clinical symptoms, antibiotic resistance patterns, and disease duration. These findings highlight the importance of enhanced patient monitoring and evolving treatment strategies to improve patient outcomes.*

Keywords: Antibiotic Resistance; Bacterial Infections; Pseudomonas Aeruginosa; Staphylococcus Aureus; Peritoneal Dialysis; Treatment Strategies.

Introduction

Peritoneal dialysis (PD) is a treatment that keeps thousands of patients with end-stage renal disease (ESRD) alive (Blake, 2001). In contrast to hemodialysis, which requires patients to visit a clinic multiple times per week, PD can be self-administered at home, providing patients with flexibility and independence (François and Bargman, 2014). Utilizing the peritoneal membrane as the natural filter to remove waste products from the circulation, this procedure involves the infusion and drainage of the specialized solution through a catheter into the peritoneal cavity (Qureshi et al., 2023). Despite its benefits, PD is associated with certain complications, the most significant and frequent being bacterial infections, predominantly peritonitis (Akoh, 2012).

Peritonitis is the inflammation of the peritoneal membrane, which is primarily a kind of bacterial infection. These infections pose hazards not only to the efficacy of PD treatment but also to the overall health and well-being of patients (Akoh, 2012; Sartelli et al., 2017). Possible sources of these bacterial infections include contamination during fluid exchanges, touch contamination, faulty or improperly placed catheters, and even systemic infections traveling to the peritoneal cavity. Staphylococcus species, such as *Staphylococcus aureus* and coagulase-negative Staphylococci, are among the most frequently prevailing pathogens in PD-related peritonitis, although a broad spectrum of bacteria can be involved (Osório et al., 2023; Tong et al., 2015).

In PD patients, bacterial infections have multiple effects. Infections can compromise the structural and functional integrity of the peritoneal membrane in the first place. This may result in diminished ultrafiltration efficiency and PD treatment failure (Yung and Chan, 2012). Persistent or recurrent infections may necessitate switching to hemodialysis, which entails its own set of challenges and lifestyle modifications. In addition, infections can result in hospitalizations, increased healthcare costs, and, in extreme cases, that may be fatal (Nguyen et al., 2019).

In addition to their direct health effects, bacterial infections have psychological and emotional consequences that cannot be avoided. Fear of infection can increase PD patients' levels of tension and anxiety. Despite its potential advantages regarding lifestyle compatibility and patient autonomy, this concern can sometimes discourage patients from selecting PD as the renal replacement therapy option (Akoh, 2012; Brito et al., 2019).

As the prevalence of chronic kidney disease and ESRD continues to rise worldwide, peritoneal dialysis will likely increase. Thus, there is a dire need for a comprehensive understanding of the impact of bacterial infections on PD patients, as well as investments in prevention, early detection, and effective management strategies. Thus, this investigation aimed to determine the clinical and psychosocial consequences and overall impact of bacterial infections in PD patients, aiming to improve patient care and outcomes.

Methodology

The research was conducted at the Nephrology Division of Khyber Teaching Hospital in Peshawar. This study was fourteen months, beginning in March 2022 and concluding in April 2023. This was a prospective observational study.

A total of 150 PD patients were included in this study. Sequential non-probability sampling was used. All patients

who met the inclusion criteria and were undergoing PD during the study duration were considered for this study. Inclusion criteria were patients 18 years or older, undergoing peritoneal dialysis at the Nephrology division of Khyber Teaching Hospital, and providing informed consent to participate in the research. Exclusion criteria were patients with a renal transplantation history, undergoing hemodialysis, or who had previously undergone it, and at the time of recruitment, patients with known systemic infectious diseases were included.

A standard data collection instrument was created to collect pertinent data. The questionnaire form contained fields for demographic information, length of PD, instances of peritonitis or other bacterial infections in the past, and specific laboratory findings regarding bacterial infections. In addition, the patient's medical history was examined for cardiovascular disorders such as cerebrovascular disorders, coronary artery disease, heart failure, and peripheral vascular disorders. Laboratory data from the first one to three months following the initiation of PD were collected.

Each patient's peritoneal dialysis fluid was collected regularly or whenever a clinical suspicion of infection existed. Under sterile conditions, the samples were cultured for bacterial proliferation. Antibiotic susceptibility testing was performed using the disc diffusion method to ascertain the appropriate antibiotic regimen for any positive cultures. Using the SPSS software version 24.0, statistical analysis was conducted. Descriptive statistics, including mean, median, and standard deviation, were calculated for continuous variables, while frequencies and percentages were determined for categorical variables. To determine associations between categorical variables, ANOVA tests were employed. A p-value of less than 0.05 was regarded as significant.

The purpose of the investigation was communicated to each patient, and written consent was obtained. Throughout the survey, anonymity and confidentiality of patient data were maintained. The research protocol was authorized by Khyber Teaching Hospital's Ethics Committee in Peshawar.

Results

Our study disclosed significant findings concerning the 150 participants undergoing peritoneal dialysis patient cohort. The mean age of PD patients was 52.3 years ($p<0.05$). A statistically significant difference ($p<0.05$) was found between the proportions of males and females regarding gender distribution: 42% males and 58% females. The average 24-hour urine output was 858 ml, and body mass index was 22.8 ($p<0.05$). On average, 55.48 months had passed since the insertion of the PD catheter ($p<0.05$). Among the causes of ESRD, glomerulonephritis was the most prevalent at 44.66 percent, followed by hypertension and diabetic nephropathy with a significant distribution ($p<0.05$). Diabetes (41.33%), cardiovascular disease (30%), and hypertension (48.66%) were also statistically significant ($p<0.05$ Table 1).

The study examined bacterial infections in 150 PD patients. *Staphylococcus aureus* was the most prevalent bacterial infection, with 22 cases representing 14.67% of the cohort ($p<0.05$). Streptococci followed, affecting 18 patients (12 percent). *Escherichia coli* was detected in 13 patients, *Pseudomonas aeruginosa* infected 10 patients (6.67%), and Enterococcus was detected in 7 patients ($p<0.05$), whereas

Klebsiella was the least prevalent pathogen, with 3 cases ($p<0.05$). The presented p-values reveal varying statistical significance for each bacterial infection in the study context (Table 2).

Clinical symptoms varied among patients diagnosed with bacterial infections during peritoneal dialysis. The most prevalent symptom was fever, experienced by 53.30% of the infected group. In close proximity, 46.70% experienced abdominal distress. Indicative of a potential infection, cloudy PD fluid was observed in 33.30% of the cohort. Twenty percent of the infected cohort reported nausea as the least common symptom (Figure 1). In this cohort of patients undergoing PD, numerous cardiovascular conditions were observed. The most prevalent was coronary artery disease, identified in 30 patients (20%) of the study population. Twenty-five patients (16.70%) of the group were diagnosed with cerebrovascular disorders. Twenty individuals (13.30%) of the sample were diagnosed with heart failure. Peripheral vascular disease was the least prevalent, affecting just 10 participants (6.70%) (Figure 2).

The study examined the susceptibility of various bacterial strains to commonly prescribed antibiotics among patients undergoing PD infected with bacteria. Vancomycin was prescribed for *Staphylococcus aureus*-related infections. 77% of these cases exhibited sensitivity, 14% were resistant, and 9% were intermediate ($p<0.05$). Streptococci infections were predominantly treated with penicillin, which exhibited 81% sensitivity. The drug for *Escherichia coli* was ciprofloxacin, which exhibited 68% sensitivity, 22% resistance, and 10% intermediate reactions ($p<0.05$). Patients with *Pseudomonas aeruginosa* infections were also administered ciprofloxacin with a sensitivity of 55% and resistance of 30%. Ampicillin was used to combat Enterococcus infections. In 70% of cases, the treatment was sensitive, and 15% were resistant ($p<0.05$). Cefepime was used to treat Klebsiella infections, attaining 67% sensitivity, 25% resistance, and 8% intermediate response ($p<0.05$). The diverse levels of antibiotic sensitivity and resistance among various bacterial strains, which have significant implications for the treatment protocols of peritoneal dialysis patients, were reported in this investigation (Table 3).

The relationship between PD duration and bacterial infections indicated that 13.30% of patients on PD for 0-6 months experienced infections, 16.70% for 7-12 months, 20% for 13-18 months, and 50% for 19 months or longer (Figure 3). The outcomes of bacterial infections in PD patients described that 60 percent of those infected recovered without complications. One-seventh of the patients experienced minor complications that were effectively managed. 8.3% of patients required hospitalization due to severe complications. A small percentage, 4.2%, had to discontinue PD due to these complications, and another 4.2% tragically perished due to the severity of their infections (Table 4).

According to the study, significant variations in laboratory parameters were found among PD patients with bacterial infections. The average hemoglobin concentration decreased to 9.89 g/dl ($p<0.05$). The average number of white blood cells increased by 15 $\times 10^9$/L ($p<0.05$). The mean platelet count was 233.46 x 1000/ml ($p<0.05$). Average C-reactive protein levels were elevated by 25 mg/L ($p<0.05$). Serum creatinine levels increased by an average of 2.5 mg/dL, while sodium levels decreased by an average

of 109.35 mmol/l (p<0.05). Other parameters, including serum albumin, phosphorus, blood urea nitrogen, and uric acid, exhibited significant deviations from their normal values (Table 5).

The study's findings on prior episodes of bacterial infections among PD patients showed that 46.7% had no previous episodes. Meanwhile, 26.7% had experienced one episode, 16.7% had two, and 10% encountered three or more episodes (Figure 4). In evaluating the duration of bacterial infections in patients with PD, it was determined that 26.7% of infected patients experienced symptoms for 1-3 days. A greater proportion, 40 percent, exhibited symptoms lasting 4-7 days. In the meantime, 20% reported symptoms lasting between 8 and 14 days, and 13.3% reported symptoms lasting longer than 15 days (Figure 5).

Table 1: Demographic Characteristics of the Participating Population

Variable	Number (n=150)	Percentage (%)	p-value
Age (mean ± SD)	52.3 ± 10.19	---	0.025*
Gender			
Male	63	42.0	0.007*
Female	87	58.0	
Urine output			
(ml/ 24 hours duration)	858 ± 132	-----	0.038*
Body mass index	22.8 ± 2.43		0.024*
Months following the insertion of the PD catheter	55.48 ± 10.10	-----	0.031*
Cause of ESRD			
Diabetic nephropathy	32	21.34	
Hypertension	51	34.0	0.0001*
Glomerulonephritis	67	44.66	
Comorbid Conditions			
Diabetes	62	41.33	
Cardiovascular Disease	45	30.0	0.0001*
Hypertension	73	48.66	
*indicated the significant values			

Table 2: Incidence of bacterial infections in PD patients

Type of Bacterial Infection	Number (n=150)	Percentage (%)	p-value
Staphylococcus aureus	22	14.67	0.024*
Streptococci	18	12.0	0.031*
Escherichia coli	13	8.67	0.049*
Pseudomonas aeruginosa	10	6.67	0.051*
Enterococcus	07	4.67	0.057*
Klebsiella	03	2.0	0.067*
*indicated the significant values			
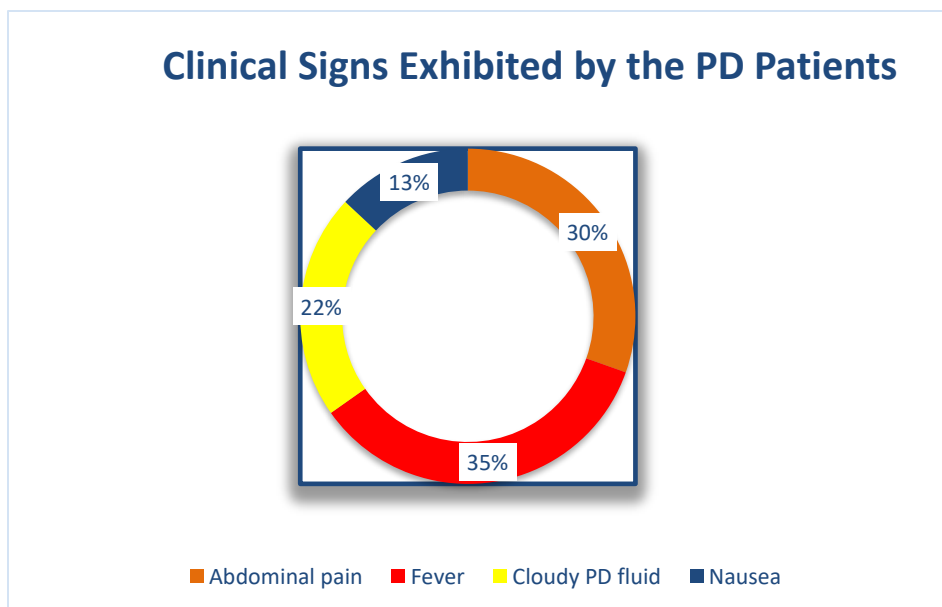
Figure 1: Clinical Symptoms at Presentation of Infection

Cardiovascular History of the Study Population

Figure showing horizontal bar chart with the following values:
- Peripheral vascular disease: 10
- Heart failure: 20
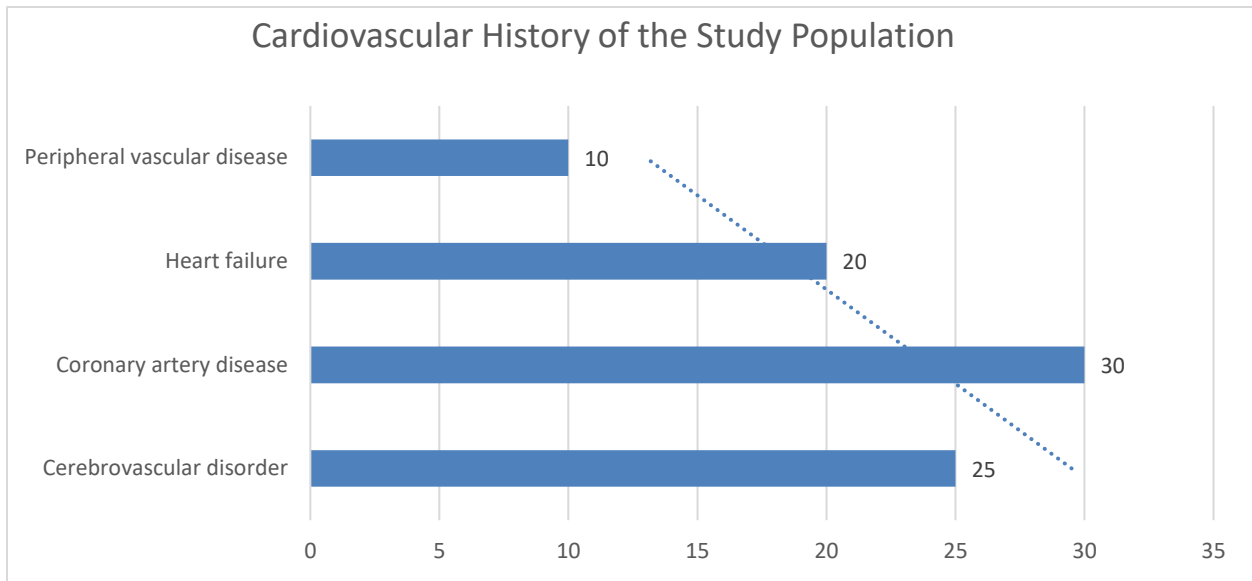- Coronary artery disease: 30
- Cerebrovascular disorder: 25

Figure 2: Cardiovascular History of the Study Population

Table 3: Antibiotic susceptibility of detected bacteria against the routinely used antibiotics

Bacteria	Antibiotic Name	Sensitive (%)	Resistant (%)	Intermediate (%)	p-value
Staphylococcus aureus	Vancomycin	77	14	09	0.0001*
Streptococci	Penicillin	81	13	06	0.0001*
Escherichia coli	Ciprofloxacin	68	22	10	0.0023*
Pseudomonas aeruginosa	Ciprofloxacin	55	30	15	0.0019*
Enterococcus	Ampicillin	70	15	15	0.0001*
Klebsiella	Cefepime	67	25	08	0.0001*
*indicated the significant values					

Number of Infections IN PD DURATION

Figure showing horizontal bar chart with the following values:
- 19+: 20
- 13-18: 30
- 12-Jul: 25
- 0-6: 20
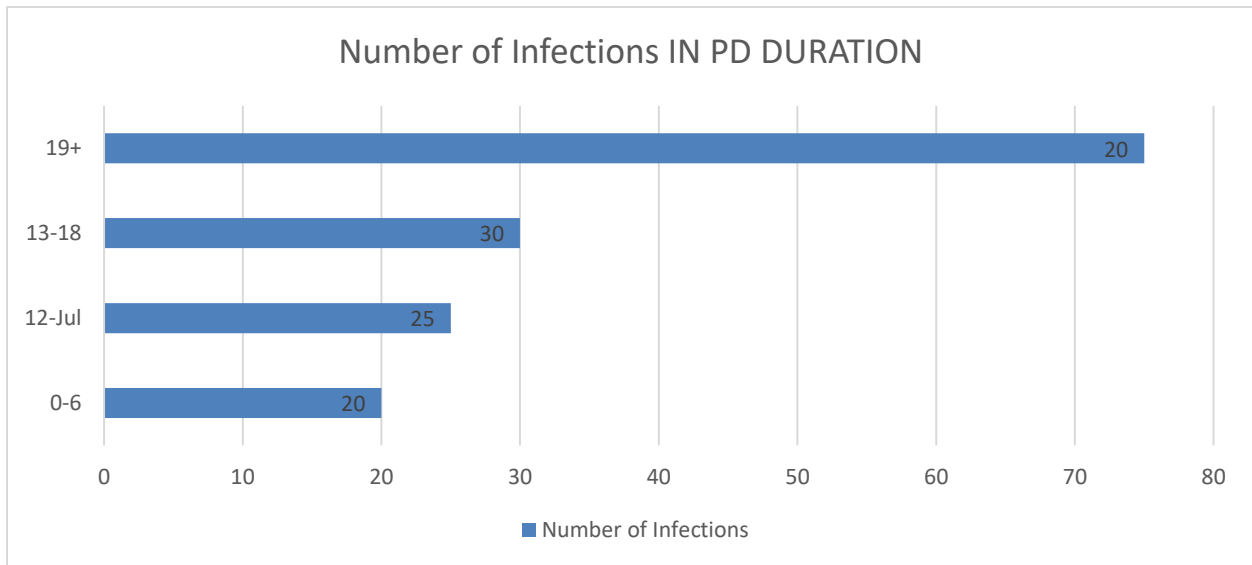
■ Number of Infections

Figure 3: Duration of PD vs. bacterial infection incidence

Table 4: Patient Outcomes Post-Infection

Outcome	Number of Patients	Percentage of Total Infected
Recovery with no complications	70	60%
Minor complications (managed)	20	17%
Severe complications (hospitalized)	10	8.3%
Discontinued PD due to complications	5	4.2%
Mortality	5	4.2%

Table 5: Laboratory Parameters of PD Patients with Bacterial Infections

Laboratory Parameter	Normal Range	Mean Value in Infected Patients	Standard Deviation	p-value
Hemoglobin (g/dl)	12-18	9.89	2.13	0.043*
White Blood Cell Count (10^9/L)	4-11	15	3.22	0.012*
Platelets (x1000/ml)	150-400	233.46	36.09	0.039*
C-Reactive protein (mg/L)	<5	25	8.59	0.001*
Serum Creatinine (mg/dL)	0.7-1.3	2.5	0.80	0.025*
Serum Albumin (g/dl)	3.4-5.4	3.42	0.78	0.060*
Serum Phosphorus (mg/dl)	3.4-4.5	5.4	1.82	0.019*
Blood urea nitrogen (mg/dl)	6-24	73.2	8.92	0.001*
Uric acid (mg/dl)	3.5-7.0	6.78	2.21	0.042*
Sodium (mmol/l)	135-145	109.35	43.98	0.008*
*indicated the significant values				
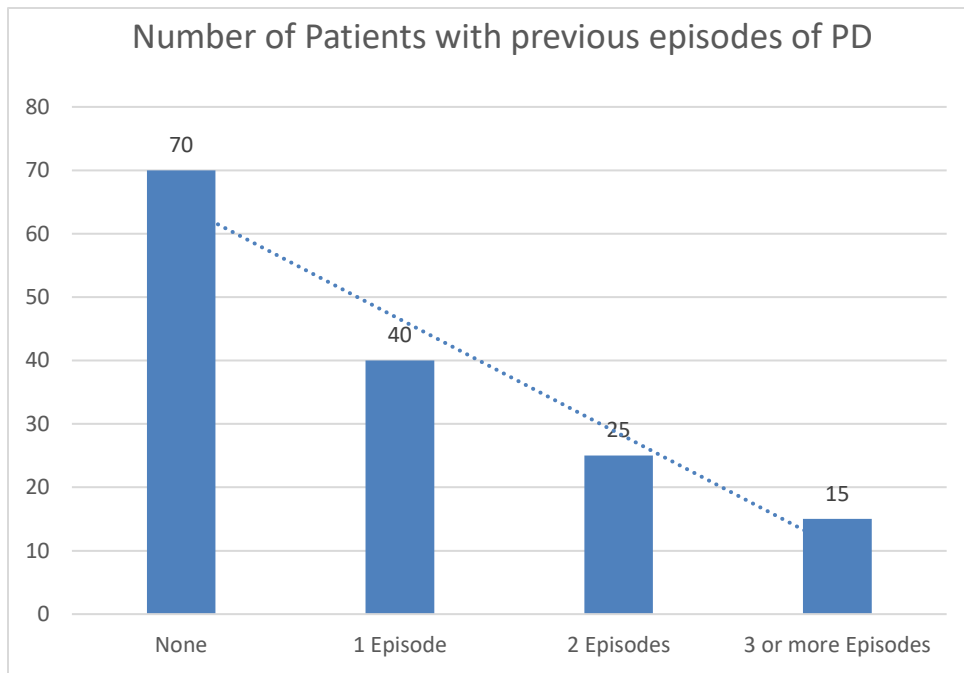
Figure 4: History of Previous Peritonitis Episodes
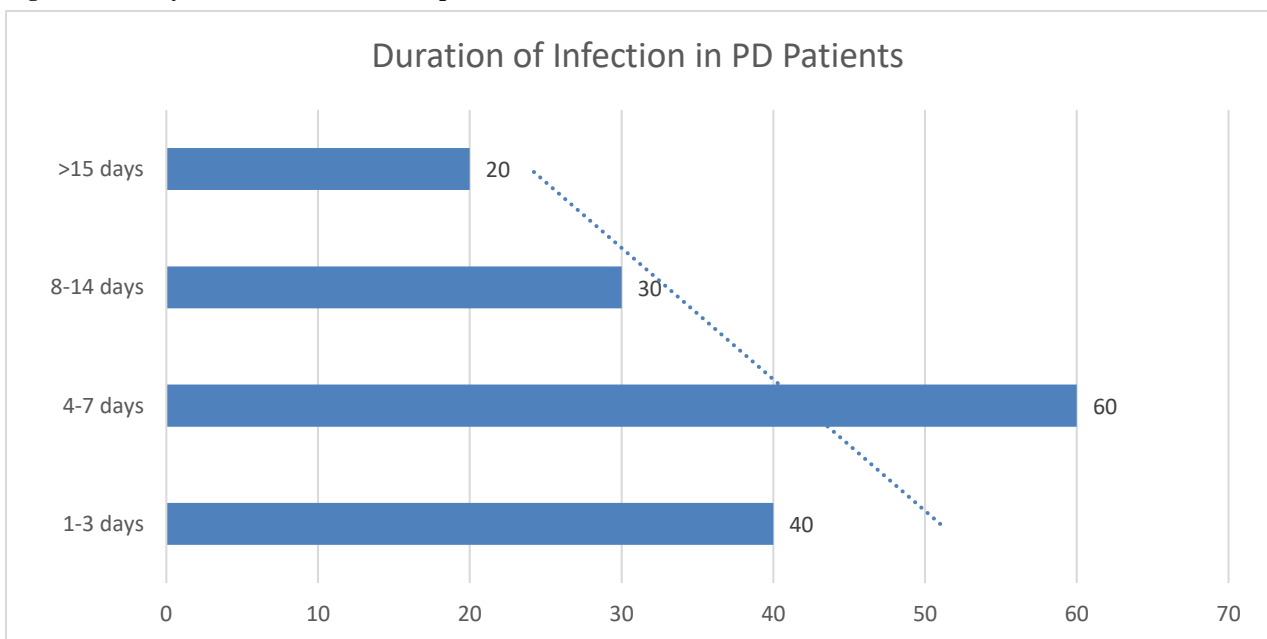
Figure 5: Duration of Hospital Stay for Infected PD Patient

Discussion

The medical community has long been concerned about the repercussions of bacterial infections in patients with peritoneal dialysis. Our research sheds new light on this vital topic. The findings confirmed that bacterial infections significantly played a crucial part in PD patients' physical health. The age and gender distributions identified in this study were consistent with prior research indicating that PD is commonly observed in patients around 50 with a modest female predominance (Wang et al., 2019). Our findings on the leading cause of ESRD mirrored global data, with glomerulonephritis being the most prevalent, a conclusion supported by studies reporting that glomerulonephritis remained the leading cause of ESRD worldwide (Ali et al., 2018; Halle et al., 2015; Kazi and Hashmi, 2020).

Our identification of *Staphylococcus aureus* as the leading causative agent in bacterial infections among PD patients is consistent with previous research (Scheuch et al., 2019; Wang et al., 2019). Notably, however, the prevalence of Streptococci and *Escherichia coli* is similar, highlighting the need for ongoing monitoring and early intervention in the patient population.

The predominant clinical manifestations observed, fever and abdominal pain, are consistent with previously reported symptoms of peritoneal infections (Poulsen et al., 2018). In addition, the prevalence of cardiovascular comorbidities among PD patients, specifically coronary artery disease, is consistent with global findings (Kendir et al., 2018). It was previously identified that there is an interconnected pathophysiology between PD, bacterial infections, and cardiovascular complications (Kendir et al., 2018).

Concerning antibiotic sensitivity and resistance patterns, the high sensitivity of *Staphylococcus aureus* to vancomycin and Streptococci to penicillin is consistent with findings from prior research (Onwubiko and Sadiq, 2011). However, the resistance in strains towards ciprofloxacin, particularly in *Pseudomonas aeruginosa*, emphasizes the evolving bacterial resistance patterns and the need for periodic antibiotic susceptibility studies (Shariati et al., 2022). In accordance with the findings of Akoh et al. (2012), the observed correlation between the duration of PD and the incidence of bacterial infections highlighted the increased susceptibility of long-term PD patients to infection. The post-infection outcomes, including the lamentable mortality rate, demonstrated the severity of bacterial infections in this patient population (Akoh, 2012; Curty et al., 2014).

Conclusion

This study found significant correlations between bacterial infections and various clinical, demographic, and physiological parameters. The patient group, predominantly infected with *Staphylococcus aureus*, displayed notable clinical symptoms, including fever and abdominal pain. In cases involving *Pseudomonas aeruginosa*, antibiotic susceptibility testing revealed an evolving resistance pattern, especially to ciprofloxacin. Moreover, the protracted duration of PD corresponded to increased infection susceptibility, and laboratory parameters, particularly C-reactive protein, exhibited marked deviations during episodes of bacterial infection. The research emphasized the urgent need for targeted interventions,continuous monitoring, and evolving treatment protocols for PD patients to mitigate bacterial infections' effects.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department Concerned.
Consent for publication
Approved
Funding
Not applicable

Conflict of interest

The authors declared an absence of conflict of interest.

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