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Original article

Dialysis-associated pathogens at King Fahad Hospital of the University, Eastern Province, Saudi Arabia

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Abstract. *Background and aim:* Microbial infection among dialysis patients is a major health problem with several outcomes including morbidity, mortality, as well as hospitalization. Detection of the prevailing pathogens and their predictors in dialysis patients is crucial to their management and prevention. *Methods:* A retrospective observational study was conducted in King Fahd Hospital of the University to illustrate the burden of dialysis-associated pathogens, and to assess the association between patients' characteristics and the occurrence of infection and their role as predictors. *Results:* The study included all patients who underwent dialysis and had associated infections confirmed by blood culture between 1990 to 2022. A total of 485 dialysis patients were included in the study. Half of the dialysis patients (51%) had pathogenic infections. The most common pathogen among hemodialysis was *Staphylococcus aureus* followed by *Pseudomonas aeruginosa*. In peritoneal dialysis, the most common pathogen was *Staphylococcus aureus* followed by *Staphylococcus epidermis*. Old age (61-80 years), male sex, and hemodialysis were associated with an increased risk of infection (*P* value <0.05). *Conclusion:* Bacteria, namely *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Staphylococcus epidermis*, were the most common pathogens in dialysis patients. Among all studied patients' characteristics only old age (60-80 years) and being male was associated with the occurrence of infection in all dialysis patients. (www.actabiomedica.it)

Key words: pathogens associated dialysis, bacteria, hemodialysis, peritoneal dialysis, eastern province of Saudi Arabia

Introduction

On failure of the kidney to function, the bloodstream's extra fluid and waste materials are removed through a process called dialysis.[1] In this form of renal replacement therapy, extra water, solutes, and toxins are removed by artificial machinery to assist the kidneys in filtering blood. Both acute kidney injury (AKI) and chronic kidney disease (CKD) result in a gradual decrease in kidney function and need dialysis to maintain homeostasis (1). Dialysis is a procedure to remove wastes and excess water from the blood to maintain homeostasis, it can be divided into extracorporeal dialysis and peritoneal dialysis (PD). In extracorporeal dialysis, fluid and wastes are removed from the patient's blood outside the body. Extracorporeal dialysis includes hemodialysis (HD) and hemofiltration. HD is a medical method that is used to remove extra fluid and waste materials from the blood as well as to fix electrolyte imbalances. HD removes wastes and excess water by using a dialyzer (an external filter) with a semipermeable membrane. Waste materials are

separated from the blood by producing a countercurrent flow gradient in which the fluid of the dialyzer flows in the opposite direction to the blood flow. In order to extract waste and water into the dialysate during PD, the peritoneum is used as a natural semipermeable membrane (2).

Disrupted renal function is the basic criterion for receiving dialysis. Uremic syndrome, expansion of the extracellular volume, hyperkalemia, acidosis, creatinine clearance of 10 ml per min per 1.73 m2, failure to respond to medical treatment, and bleeding diathesis are all criteria for dialysis (3). In Saudi Arabia, a total of 21,586 people were on dialysis as of the end of 2023, with 18,270 of them receiving HD and the remaining 2,316 receiving PD, according to statistics created by the Saudi Center for Organ Transplantation (SCOT) (4). Dialysis was used to treat 604 cases of end-stage renal failure per million population (PMP), 1,726 deaths overall (9%), and 294.3 cases per million population (PMP) of end-stage renal illness (4).

Infection in dialysis patients is one of the leading health risks that is associated with adverse health sequelae up to mortality (5). Research evidence indicates that the burden of infection is growing in dialysis patients. Infection risks vary to the characteristics of dialysis patients. Greater accessibility to dialysis has resulted in less stringent patient selection, as seen by an increased proportion of older patients and individuals with complex comorbid diseases (5-7). There are a variety of dialysis-associated pathogens, Coagulase negative *Staphylococci* and *Staphylococcus aureus* contribute to 40%-80% of catheter-related bacterial site infections (CRBSIs), making them the most prevalent gram-positive bacteria that cause dialysis-associated infections. Gram negative bacteria account for 20%-40% of CRBSIs, while both fungus infections (5%) and polymicrobial infections (10%–20%) are less frequent (5). Endocarditis, septic arthritis, osteomyelitis, brain abscess, spinal epidural abscess, and septic pulmonary emboli are examples of CRBSIs' metastatic infectious consequences (8).

The most common complications of long-term HD are cardiovascular disease particularly valvular heart disorders, vascular access, renal osteodystrophy, malnutrition, Beta-macroglobulin amyloidosis, and infection transmission among HD-dependent patients (9). In comparison to PD patients, HD patients were older and had dialysis for longer periods. Both the HD and PD modalities have a similar rate of long-term problems (9,10). The main factor contributing to morbidity and mortality among dialysis patients is cardiovascular problems. Sudden cardiac death (SCD) is a common prevailing cardiovascular complication and 25% of all SCD deaths are due to dialysis. Even in patients who don't have a severe blockage of the coronary arteries on angiogram, HD has been linked to abruptly reduced myocardial blood flow (11). It is unclear but seems likely that the ischemic myocardial shock brought on by dialysis can cause a dangerous arrhythmia or that it serves as a risk factor for heart failure in dialysis patients (12).

Observational studies findings can help with infection management and planning of prevention in dialysis patients. We aimed to detect the pathogens prevalence in dialysis patients and assess the association between the burden of pathogens in dialysis patients and patients' characteristics, as well as to assess these characteristics as predictors for the occurrence of infections in dialysis patients.

Methods

This is a retrospective hospital-based observational study in King Fahd Hospital of the University (KFHU), Imam Abdulrahman Bin Faisal University (IAU) in Al Khobar, Saudi Arabia. Data from 485 patients was retrieved from lab reports and electronic health records of the hospital. This study included all adult and pediatric patients who underwent dialysis (HD, PD, or both) and had blood cultures at KFHU between 1990 to 2022. In each case, two samples were collected, a blood sample and a sample from the catheter, at the same time, if the same organism is isolated from both samples, then bacteriemia is considered to be related to the catheter.

All the study methods were carried out following relevant guidelines and regulations and were ethically approved by the ethical committee of the deanship of scientific research at IAU with IRB number (IRB-UGS-2022-01-405). The patient's confidentiality was maintained because no identifying information was

used, the patient's data was collected after ethical approval by the deanship of scientific research at IAU (IRB-UGS-2022-01-405) and permission of the microbiology laboratory, KFHU, and microbiology department, college of Medicine, IAU.

The patients' data included demographic data (sex, age, nationality), clinical data (kidney and non-kidney comorbidities and outcome of the pathogenic infection [cure, recurrence rate, peritonitis, pneumonia, developing of sepsis and death]), microbiological data (the name and type of pathogen [bacterial, viral, fungal, and parasitic]) and dialysis data (type of dialysis, reason of dialysis, frequency of dialysis, site of catheter insertion for PD, type of catheter and duration of dialysis).

Data were imported from an Excel spreadsheet, organized, and analyzed using the soft-ware Statistical Package for the Social Sciences (SPSS) version 25. Means and standard deviations (SD) or median were used to represent descriptive data, whereas numbers or percentages were used to summarize data. The Chi-square test was used to compare the type of pathogen, risk of infection, and outcome of infections between the three groups of dialysis (HD, PD, and both types of dialysis) and the *P* value. A logistic regression model was utilized to assess patients' characteristics as an estimated risk of infection in dialysis patients. A statistically significant result was considered if *a P*-value of 0.05 or less.

Results

A total of 485 patients were included in the study, 51% (246/485) of them were infected and had dialysis-associated pathogens. Regarding the type of dialysis 77% (372/485) of patients were on HD, 14% (68/485) patients were on PD and 9% (45/485) patients were on both types of dialysis. Regarding sex, 59% (285) of the participants were males and 41% (200) of the patients were females. The majority of the patients (40% [195/485]) were old age (61-80 years old). 90% (440/485) of the patients were Saudi. The most common comorbidity was end-stage renal disease (ESRD) (90%) in patients who had kidney diseases and Diabetes mellitus (DM) (61%) in patients who hadn't kidney diseases. The patients' demographic, co-morbidity, and dialysis data of different types of dialysis was presented in Table 1.

The pathogens associated with dialysis patients is presented in Figures 1 and 2. Pathogens were detected in half of dialysis patients (50.7% [246/485]), 182 receiving HD, 29 receiving PD and 35 using both types of dialysis.

Seventeen bacteria were detected in dialysis patients (Figure 1). The most prevailing bacterial pathogens were *Staphylococcus aureus, Pseudomonas aeruginosa* and *Staphylococcus epidermis* (*P value* > 0.05). In HD patients, *Staphylococcus aureus* was the most prevailing bacteria followed by *Pseudomonas aeruginosa*. In PD

Table 1. Demographic, co-morbidity, and dialysis data of patients who underwent different dialysis.

			HD (n= 372)	PD (n=68)	Both (n=45)	Total (n=485)
Demographic data	Mean Age (SD)		58.4 (16.79)	53.7 (20.27)	54.8 (18.64)	-
	Age group	18-40	69 (18.5%)	20 (29%)	12 (27%)	101 (21%)
		41-60	115 (31%)	21 (31%)	13 (29%)	149 (31%)
		61-80	157 (42%)	21 (31%)	17 (38%)	195 (40%)
		>80	31 (8.5%)	6 (9%)	3 (6%)	40 (8%)
	Sex	Female	143 (37.5%)	31 (46%)	26 (58%)	200 (41%)
		Male	229 (61.5%)	37 (54%)	19 (42%)	285 (59%)
	Nationality	Saudi	337 (90.5%)	64 (94%)	41 (91%)	442 (91%)
		Non-Saudi	35 (9.5%)	4 (6%)	4 (9%)	43 (9%)

Table 1 (*Continued*)

				HD (n= 372)	PD (n=68)	Both (n=45)	Total (n=485)
Co-morbidities*	Kidney disease	Yes	ESRD	351 (94%)	64 (94%)	44 (98%)	459 (95%)
			PKD	7 (2%)	2 (3%)	-	9 (2%)
			AKI on top of ESRD	11 (3%)	-	1 (2%)	12 (2.4%)
			GN	3 (1%)	2 (3%)	-	3 (0.6%)
		No	DM	231 (62%)	38 (56%)	28 (62%)	297 (61%)
			HTN	309 (83%)	49 (72%)	38 (84%)	396 (81.6%)
			CVD	112 (30%)	17 (25%)	6 (13%)	135 (28%)
			Stroke	26 (7%)	4 (5%)	5 (11%)	35 (7%)
			Liver Disease	7 (2%)	3 (4%)	2 (4%)	12 (2.5%)
			DLP	33 (9%)	1 (2%)	3 (6%)	37 (7.6%)
			Frailty**	41 (11%)	4 (5%)	2 (4%)	47 (9.7%)
Dialysis data	Reason for Dialysis	ESRD	ESRD	316 (85%)	53 (78%)	40 (89%)	409 (84%)
			AKI on top of ESRD	11 (3%)	1 (3%)	-	12 (2.5%)
			Diabetic nephropathy	2 (0.5%)	-		2 (0.5%)
			Hypertensive kidney disease	4 (1%)	-	-	4 (1%)
			PKD	7 (2%)	2 (3%)	-	9 (2%)
			Unknown	32 (8.5%)	12 (16%)	5 (11%)	49 (10%)
	Duration of dialysis		< 1 Month	12 (3%)	4 (6%)	2 (4%)	18 (4%)
			1-6 Months	18 (5%)	4 (6%)	4 (8%)	26 (5.2%)
			1- 5 Years	210 (56%)	22 (32%)	17 (38%)	249 (51.3%)
			5-10 Years	48 (13%)	14 (21%)	6 (13%)	68 (14%)
			>10 Years	51 (14%)	13 (19%)	5 (11%)	69 (14.2%)
			Unknown	33 (9%)	11 (16%)	11 (26%)	55 (11.3%)
	Frequency of Dialysis		Daily	10 (3%)	32 (47%)	12 (27%)	54 (11%)
			More than two a week	280 (75%)	14 (21%)	14 (31%)	308 (63.5%)
			Twice a week	51 (14%)	8 (12%)	7 (14%)	66 (13.6)
			Once a week	5 (1%)	1 (2%)	1 (3%)	7 (1.5%)
			Unknown	26 (7%)	13 (18%)	11 (25%)	50 (10.3)
	Type of vascular access used in HD		Arteriovenous fistula	200 (53%)	-	15 (34%)	215 (51.6%)
			Central venous catheter	110 (30%)	-	19 (42%)	129 (31%)
			Tunneled femoral vein catheter	6 (2%)	-	5 (11%)	11 (2.6%)
			Unknown	56 (15%)	-	6 (13%)	62 (14.8%)
	Type of vascular access used in PD		Single-cuff catheters	-	13 (19%)	2 (4%)	15 (13.3%)
			Double-cuff catheters	-	9 (10%)	5 (11%)	14 (12.4%)
			3 Cuff catheters	-	8 (12%)	7 (16%)	15 (13.3%)
			Unknown	-	38 (59%)	31 (69%)	69 (61%)

* Many patients have multiple comorbidities. Abbreviations: CVD: Cardiovascular Disease, DLP: Dyslipidaemia, GN: Glomerulonephritis, HTN: Hypertension, PKD: Polycystic Kidney Disease. **Frailty: a clinical syndrome in older adults, it is a state of increased vulnerability and increased risk for adverse health outcomes, resulting from aging-associated decline in reserve and function across multiple physiologic systems.

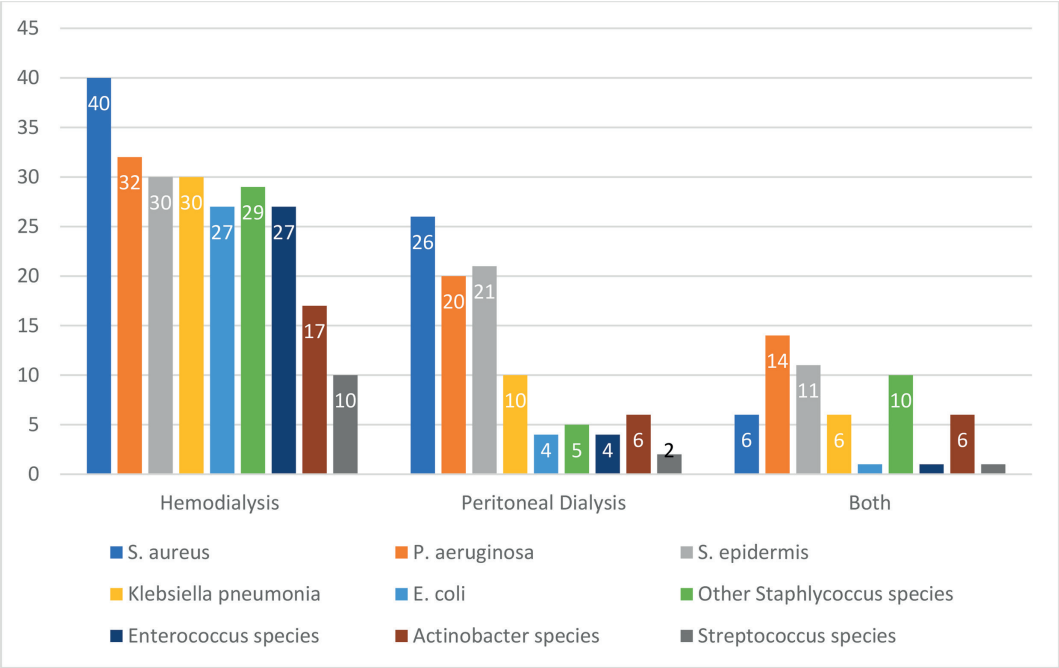

Figure 1. Dialysis and associated Bacterial Pathogens. P value = 0.765 (Statistically insignificant). * *S. aureus*: *Staphylococcus aurues*, *S. epidermis*: *Staphylococcus epidermis*, *P. aeuginosa*: *Pseudomona aeruginosa*, *E. coli*: *Escherichia coli*.

the most common bacterial pathogen was *Staphylococcus aureus* followed by *Staphylococcus epidermis*. In patients undergoing both HD and PD, the most common bacterial pathogen was *Pseudomonas aeruginosa* followed by *Staphylococcus epidermis*. Nine fungal infections were detected in dialysis patients (figure 2). The most predominant fungal pathogen was *Candida albicans* (*P value* > 0.05).

A total of 129 (52.4%) patients were infected with a single pathogen, most of them (121 cases) had bacterial infection and only 8 of them had single fungal infection (table 2). While 117 (47.6%) of the dialysis patients were infected with multiple pathogens, the majority (94/117) were bacterial-bacterial infections and 23/117 had bacterial-fungal infections. The details of single and multiple infections are presented in Table 2.

Outcome of the pathogenic infection in dialysis patients is presented in Table 3. Recurrence of infection was the predominant outcome of infections, 31% (76/246), particularly patients with both dialysis (49%) and PD (38%).

The association of patients' characteristics with the occurrence of infections in dialysis patients was done and presented in Table 4. Among all studied variables only old age and being male sex showed a statistically significant association with occurrence of infection in all dialysis patients (Table 4).

The standardized coefficients can be used to compare the relative importance of the predictors when predictor variables were measured at different scales. The patients' characteristics were analyzed by standardized regression coefficient as predictors of occurrence of dialysis-associated pathogens (dependent variable) (Table 5). The patients' characteristics, age (*P* value = 0.001), sex (*P* value = 0.033), and type of dialysis (*P* value = 0.018) were predictors for the occurrence of infection in dialysis patients with statistically significant *P value* (< 0.05) (table 5). Age has the highest standardized coefficient, indicating that it is the most important predictor in the model. The coefficients for sex and type of dialysis are also relatively high. The R Square value of 0.332 indicates that the predictors in the model explain 33.2% of the variation

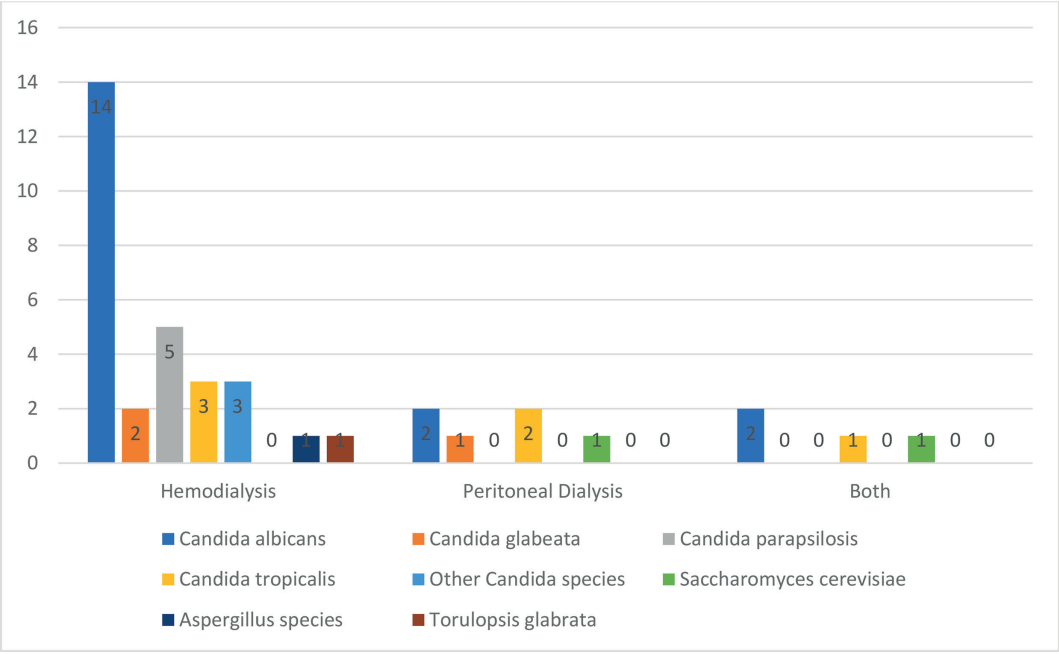

Figure 2. Dialysis and associated fungal pathogens. P value = 0.509 (Statistically insignificant).

Table 2. Infection by single and multiple pathogens in dialysis patients.

Pathogen		**HD**	**PD**	**Both**	**Total**	***P value***
Single pathogen	Bacterial	97 (80%)	12 (10%)	12 (10%)	121 (100%)	0.3593
	Fungal	5 (62.5%)	1 (12.5%)	2 (25%)	8 (100%)	
	Total	102 (79%)	13 (10%)	14 (11%)	129 (100%)	
Multiple pathogens	Bacterial-Bacterial	62 (66%)	13 (14%)	19 (20%)	94 (100%)	
	Bacterial-Fungal	18 (78%)	3 (13%)	2 (9%)	23 (100%)	
	Total	80 (68%)	16 (14%)	21 (18%)	117 (100%)	
Total		182 (74%)	29 (12%)	35 (14%)	246 (100%)	

* Statistically significant if *P value* < 0.05).

Table 3. Outcome of infections in dialysis patients.

		HD (n=182)	**PD (n=29)**	**Both (n=35)**	**Total (n=246)**
Undesirable outcome	Recurrence	48 (26%)	11 (38%)	17 (49%)	76 (31%)
	Peritonitis	-	-	4 (11%)	4 (1.6%)
	Pneumonia	2 (1%)	-	-	2 (1%)
	Sepsis	2 (1%)	1(3%)	-	3 (1.2%)
	Shock	2 (1%)	-	2 (6%)	4 (1.6%)
	Death	2 (1%)	-	1 (3%)	3 (1.2%)
	Total	56 (30%)	12 (41%)	24 (69%)	92 (37.4%)
Cure		126 (70%)	17 (59%)	11 (31&)	154 (62.6%)
Total		182 (100%)	29 (100%)	35 (100%)	246 (100%)

Table 4. Table of association between occurrence of infection in dialysis patients and patients' studied characteristics.

					HD (n=372)		PD (n=68)		Both (n=45)		Total (n=485)	
					Yes/No (182/190)	*P value*	Yes/No (29/39)	*P value*	Yes/No (35/10)	*P value*	Yes/No (246/239)	*P value*
Demographic data	Age		18 - 40		25/44	0.006*	8/12	0.039*	9/3	0.213	39/62	0.029*
			41 - 60		49/66		8/13		8/5		65/84	
			61 - 80		82/75		11/10		15/2		108/87	
			>80		26/5		5/1		3/0		34/6	
	Sex		Female		72/71	0.004*	12/19	< 0.0001*	23/3	0.195	107/93	<0.0001*
			Male		110/119		17/20		12/7		139/146	
	Nationality		Saudi		165/172	0.144	28/36	0.996	31/10	0.627	224/218	0.116
			Non-Saudi		17/18		1/3		4/0		22/21	
Co-morbidity	Yes		Kidney disease	Yes	180/176	<0.0001*	28/33	0.762	35/9	0.927	246/192	0. 091
				No	182/190		29/39		35/10		246/239	
	No		-		-		-		-		-	
Dialysis data	Reason for dialysis	ESRD	ESRD		157/160	0.305	24/29	0.201	32/8	0.4210	213/197	0.891
			AKI on top of ESRD		5/6		1/0		0/1		6/6	
			Diabetic nephropathy		1/1		-		1/0		2/1	
			Hypertensive kidney disease		1/3		-		-		1/3	
			PKD		4/3		0/2		-		4/3	
	Duration of dialysis	NA			14/18		3/9		2/1		20/29	
		< 1 Month			4/8	0.678	0/4	0.092	1/1	0.092	5/13	0.165
		1-6 Months			7/11		0/4		1/3		8/18	
		1- 5 Years			95/115		9/13		15/2		119/130	
		5-10 Years			25/23		6/8		5/1		36/32	
	Frequency of dialysis	>10 Years			39/12		9/4		3/2		51/18	
		NA			12/21		5/6		10/1		27/28	
		Daily			6/4	0.814	16/16	0.098	11/1	0.874	33/21	0.194
		> twice a week			144/136		8/6		10/4		162/146	
		Twice a week			26/25		1/7		4/3		31/35	
	Type of catheter used in HD	Once a week			1/4		0/1		1/0		2/5	
		NA			5/21		4/9		9/2		18/32	
		Arteriovenous fistula			90/110	0.429			12/3	0.212	113/215	0.098
		Central venous catheter			64/46				14/5		51/129	
		Tunneled femoral vein catheter			2/4				4/1		5/11	
	Type of catheter used in PD	NA			26/30				5/1		31/31	
		Single cuff catheter					1/12	0.1887	2/0	0.380	3/12	0.189
		Double-cuff catheters					3/4		4/1		8/5	
		3 Cuff catheters					3/5		5/2		8/7	
		NA					22/18		24/7		47/22	

* Statistically significant if *P value* < 0.05.

Table 5. Standard regression coefficient for predicting pathogens in dialysis patients.

Coefficients (Dependent Variable: Pathogens)	**Standardized Coefficients**	**t**	**Significance (*P* value)**
(Constant)	1.875	0.743	0.462
Age	0.319	1.299	0.001*
Sex	0.698	1.114	0.033*
Nationality	0.264	-0.572	0.567
Co-morbidities	0.019	0.389	0.698
Catheter used in HD	0.128	-0.582	0.561
Type of dialysis	0.412	1.387	0.018*
Reason for dialysis (All patients)	0.055	-1.042	0.298
Duration of dialysis (All patients)	0.052	-0.748	0.456
Frequency of dialysis (All patients)	0.107	-1.644	0.107
R= 0.576 **R Square =** 0.332 **Adj. R Square =** 0.215 **Estimate Std. Error =** 2.179			

* Statistically significant if *P value* = < 0.05.

that occurs in the dependent variable, while the Adjusted R Square value of 0.215 suggests that the model may not fit the data very well.

Discussion

Patients with dialysis are at risk for microbial infections, which is a major health problem with several outcomes including morbidity, mortality, as well as hospitalization (5). There is an increase in the burden of infection among patients with dialysis worldwide. In the current study, microbial infections occurred in 50% of patients on dialysis, particularly patients on HD, who were old and had a comorbid disease (5-7).

In the present study, the bacteria *Staphylococcus aureus* was the most common pathogen among patients with dialysis, it occurred in 72 (15%) cases, followed by *Pseudomonas aeruginosa* which accounted for 66 (13.5%) of cases. HD patients showed the highest rate of infections among dialysis patients. Similarly, Sanavi et al. (13) noticed that the most common pathogen among HD was *Staphylococcus aureus* accounting for 42% of the cases. Abdulrhman et al. (14) noticed that *Staphylococcus aureus* accounted for 77% of the infections. Moreover, Goetz et al. (15) reported that the most common pathogen among HD patients was *Pseudomonas aeruginosa* accounting for 59% of the cases. Wagnild et al. (16) found that 10 out of the 17 HD patients had *Pseudomonas aeruginosa* with a high rate of bacteremia.

The most common pathogens detected in PD patients were *Staphylococcus aureus* followed by *Staphylococcus epidermis* and *Pseudomonas aeruginosa* accounting for 26, 21, and 20 cases respectively. Hwang et al. (17) found that the most common pathogens among PD in South Korea were *Staphylococcus epidermidis* and *Staphylococcus aureus*. Salzer et al. (18) found that *Staphylococcus epidermis* were the common pathogens encountered in patients with PD and is associated with peritonitis. Furthermore, Luvira et al. (19) found that Coagulase-negative *Staphylococcus*, *Staphylococcus aureus* and *Pseudomonas* spp. were the main pathogens among PD patients, 15.9%, 15.2% and 14.2%, respectively.

In spite, that associated comorbidity was a high-risk factor and predictor of infection associated dialysis in many studies (9-12), in our study there was no association in-between with statistical significance. These studies reported that besides having more risk of infections, dialysis patients had other frequent long-term sequelae such as cardiovascular disease (commonly

valvular diseases and sudden cardiac death), renal osteodystrophy, amyloidosis, and malnutrition in both types of dialysis (HD and PD).

In our study, the occurrence of microbial infection in patients with dialysis was statistically significantly associated with the patient's age, patient's sex, and the type of dialysis (HD and using both dialysis). HD and PD can be used in combination in patients with ESKD to specifically clear the solute, control blood pressure, and improve the management of fluid volume, which leads to improvement of health-related quality of life (20).

In our study, the mean age for patients on HD was 58.4±16.79 years while that for PD was 53.7±20.27 years and it was 54.8±18.64 years for patients using both dialysis. These numbers were close to those found by Wu et al. (21), who noted the mean age of dialysis patients to be 55.0±16 years. Similarly, Bonenkamp et al. (22) reported that the mean age was 56.7±21.71 while Chen et al. (23) reported a mean age of 50 years and above.

Our study results showed that older patients (61-80 years) on dialysis were the majority of dialysis patient (38%) prone to infection with statistically significant association with development of pathogen associated dialysis. Our findings were consistent with similar studies, where the risk of infection and peritonitis was statistically significantly higher in PD patients aged above 65 than in younger patients (24,25). Can et al. (26) found that 53% of infection associated dialysis were older patients with statistical significance. Furthermore, Allon et al. (27) also noted that older age who have comorbidity burden and lower serum albumin were at high risk for infection-related death. This can be explained by the increase in accessibility to dialysis with an increased risk of development of comorbidity and an increase in the possibility of chronic kidney disease as one advances in age. Girerd et al. (28) reported that chronic kidney disease is very common among elderly patients. He attributed the high prevalence of chronic kidney disease among the elderly to the increasing prevalence of chronic diseases, DM, Hypertension (HTN), and cardiovascular diseases.

The majority of the population in our study were males (62%) and there was a statistically significant association between being male and having pathogenic infections in dialysis patients. This could be explained by the fact that males have a higher prevalence of developing CKD. In addition, most of our study were males and thus had a higher risk of infection. Similarly, Al Shohaib et al. (29) and Sanavi et al. (13) found that the majority of patients with dialysis were males, 60.6%. and 54%, respectively. In contrast, Jain et al. (30) noted that the majority of the individuals in their study were women, and they usually have a higher rate of hospital admissions and duration of hospitalization compared to men, 24% and 18%, respectively.

However, Ros et al. (31) found no difference between males and females and risk of infection in dialysis patients. However, they found that women are at higher risk of mortality from infection. Also, Weigert et al. (32) found no difference between males and females in terms of risk of infection in dialysis patients.

Frequency of dialysis could increase the risk of infection in patients undergoing dialysis. Kraus et al. (33) reported that intensive HD increases the risk of infection and infection-linked complications. Many observational studies reported that both the duration and frequency of HD were associated with an increased risk of nosocomial infection (34-36). This could be explained by the fact that patients with longer duration of dialysis will have more frequent sessions with more risk of infection. Although our study did not show a statistically significant association between microbial infection and both frequency and duration of dialysis, the majority of microbial infections were found in patients who had been on dialysis for 1- 5 years and had dialysis more than two times per week.

Using the 3-cuffs has the advantage of less dislocation of the catheter and acts as an additional protection against the occurrence of peritonitis (37). However, in our study, there was no significant association between the occurrence of infection in PD patients and the type of catheter.

There are certain limitations of our study. Being a retrospective hospital-based study, depending on recorded data and the study population only in a single center in the eastern region, it does not enable estimating the real presentation of the obtained findings and limits the extension of the study results to the population of the area/region.

Conclusion

Based on our findings, the predominant pathogen associated with dialysis was the bacteria *Staphylococcus aureus* followed by *Pseudomonas aeruginosa* and *Staphylococcus epidermidis*. Among studied patients' characteristics (demographic, clinical, and dialysis data) only having an old age (61-80 years), being male and type of dialysis were predictors for the occurrence of infection with statistical significance. This study will help to enhance our knowledge regarding the most common dialysis-associated pathogens, their prevalence, and their associated risks that will help in better management of infection in dialysis patients and strategic planning for prevention and control of these pathogens.

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