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ORIGINAL ARTICLE

Microbial Organisms' Pattern in Dialysis-Dependent Patients with Catheter-Related Bloodstream Infections

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ABSTRACT

Background: Catheter-related bloodstream infections (CRBSIs) are serious complications in patients undergoing hemodialysis through vascular catheters and are associated with increased morbidity, prolonged hospitalization, and mortality. Knowledge of the local microbial pattern and antimicrobial susceptibility is important for appropriate empirical antibiotic selection and infection control. Therefore, this study was conducted to determine the microbial pattern of CRBSIs in patients undergoing hemodialysis.

Methods: This cross-sectional study was conducted over six months from Oct 2025 to March 2026 in the Nephrology Department after approval from the Institution Research and Ethical Committee (IREB) and the College of Physicians and Surgeons Pakistan (CPSP). A total of 138 patients aged 25–70 years with CRBSIs on hemodialysis were included through consecutive non-probability sampling. Blood samples were collected for microbiological identification and antimicrobial susceptibility testing. Data were analyzed using SPSS version 25.

Results: Gram-positive organisms were the most frequent causative agents of CRBSIs, particularly Staphylococcus aureus and Staphylococcus epidermidis. Gram-negative organisms including Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter baumannii, and Enterobacter cloacae were also isolated among hemodialysis patients with catheter-related infections. Vancomycin and Linezolid showed the highest activity against Gram-positive isolates, whereas Meropenem, Amikacin, and Piperacillin–Tazobactam were the most effective agents against Gram-negative organisms.

Conclusion: Determination of the microbial organisms' pattern and antimicrobial susceptibility profile in CRBSIs among hemodialysis patients will help clinicians select appropriate empirical antibiotics, improve infection control measures, and reduce catheter-associated morbidity and mortality in the local population.

Keywords: Antimicrobial Susceptibility, Bloodstream Infection, Hemodialysis, Microbial Pattern, Vascular Catheterization

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Introduction

Chronic kidney disease (CKD) is a major global health problem affecting millions of people worldwide.

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Patients with advanced stages of CKD often require hemodialysis as a renal replacement therapy to maintain life because their kidneys are unable to adequately remove metabolic waste products, excess fluids, and electrolytes from the body (1). Although hemodialysis is an effective and lifesaving treatment, it is associated with several complications, among which infections remain one of the leading causes of morbidity and mortality (2).

Vascular access is a key part of hemodialysis and central venous catheters are often used for immediate access to dialysis or during the time required for permanent vascular access to mature. Despite their clinical importance, hemodialysis catheters are closely associated with catheter-related bloodstream infections (CRBSIs) (3). These infections occur when microorganisms access the bloodstream via the catheter, colonize the catheter surface or surrounding tissues, and an indwelling catheter greatly increases the risk of bloodstream infections compared to permanent vascular access such as arteriovenous fistulas (4).

CRBSIs are linked with increased hospitalization, health care costs, treatment failure, and mortality in hemodialysis patients (5). Factors predisposing to the development of catheter-related infection include duration of catheter use, poor hand hygiene, repeated catheter manipulation, previous history of infection and comorbidities such as diabetes mellitus and hypertension (6). Several microbial organisms are responsible for CRBSIs. Common isolates include gram positive bacteria such as Staphylococcus aureus and coagulase-negative staphylococci such as Staphylococcus epidermidis, which are part of the normal flora of the skin and may contaminate the bloodstream on catheter insertion or manipulation (7). Gram negative pathogens such as Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter baumannii and Enterobacter cloacae have also emerged as important pathogens in CRBSIs particularly in hospitalized patients (8). Fungal infections although less common can cause serious complications in immunocompromised patients (9). The spectrum of microbes causing CRBSIs varies between different healthcare settings and geographic regions, reflecting differences in infection control practices, antibiotic use, hospital environment and patient population. Healthcare-associated infections are relatively common in developing countries such as Pakistan due to overcrowding of healthcare facilities, limited resources, and inadequate infection prevention measures (10). Therefore, knowledge of the local microbial pattern is important to steer appropriate empirical antibiotic therapy and improve patient outcomes. Early diagnosis and prompt management of CRBSIs are important to decrease complications related to hemodialysis catheters. Blood culture is the gold standard test for detecting the causative microorganisms (11). Furthermore, adherence to infection control measures, proper catheter care, hand hygiene and reduced use of catheters when not needed are important strategies to prevent CRBSIs (12).

The present study was conducted to determine the frequency and pattern of microbial organisms causing catheter-related bloodstream infections in hemodialysis patients at the Institute of Kidney Diseases, Peshawar. The findings of this study will help clinicians in selecting appropriate antimicrobial therapy and improving infection control practices in the local healthcare setting.

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Methods

This cross-sectional study was conducted at the Nephrology Department, Institute of Kidney Diseases, Peshawar, over a period of six months from Oct 2025 to March 2026 after obtaining ethical approval from the Institution Research and Ethical Committee (IREB), MTI-HMC/KGMC Hayatabad Peshawar (Approval No. 2883; dated 26/09/2025), and the College of Physicians and Surgeons Pakistan (CPSP). Written informed consent was obtained from all participants prior to enrollment in the study.

A total of 138 patients were included in the study using consecutive non-probability sampling. The sample size was calculated using OpenEpi software based on the reported frequency of *Staphylococcus haemolyticus* in patients with catheter-related bloodstream infections (CRBSIs), with a confidence level of 95% and an absolute precision of 2.8%.

The study included male and female patients aged 25–70 years undergoing hemodialysis through vascular catheters who fulfilled the diagnostic criteria for CRBSIs. CRBSI was defined in patients with clinical features of fever (>38°C), chills or hypotension with laboratory evidence of a differential time to positivity of ≥2 hours or a > 3-fold higher colony count in catheter drawn blood as compared to peripheral blood cultures. Patients already on antibiotics, pregnant women and patients with endocarditis were excluded from the study. After obtaining informed written consent, demographic and clinical information was recorded using a structured pre-designed proforma. Data collected included age, gender, body mass index (BMI), residence, literacy status, socioeconomic status, occupation, duration of hemodialysis, catheter site and comorbid conditions like hypertension and diabetes mellitus.

Blood samples were collected simultaneously from the dialysis catheter lumen and a peripheral vein under strict aseptic precautions before initiation of antimicrobial therapy and transported immediately to the microbiology laboratory. The specimens were processed using the BACTEC blood culture system. Positive blood culture bottles were subcultured on Blood agar and MacConkey agar. The isolated organisms were identified by Gram staining, colony morphology, biochemical tests, and the VITEK-2 Compact system. Antimicrobial susceptibility testing was performed using the Kirby–Bauer disc diffusion method according to the Clinical and Laboratory Standards Institute (CLSI) 2024 guidelines. Bacterial isolates were categorized as Sensitive, Intermediate, or Resistant based on CLSI interpretive criteria. All microbiological investigations were performed by qualified laboratory personnel under standardized laboratory protocols to ensure quality and reproducibility.

The data was analyzed using SPSS version 25. Quantitative variables like age, BMI and duration of hemodialysis were expressed as mean ± standard deviation or median with interquartile range where applicable. Categorical variables such as gender, microbial organism pattern, catheter site, hypertension, diabetes mellitus, residence, literacy status, socioeconomic status, and occupation were presented as frequencies and percentages. Stratification of microbial organism patterns was performed according to age, gender, and catheter site to assess effect modifiers. Post-stratification Chi-square test or Fisher's exact test was applied where appropriate, and a p-value ≤0.05 was considered statistically significant.

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Results A total of 138 patients with catheter-related bloodstream infections (CRBSIs) undergoing hemodialysis were included in the study. The average age of the patients was 46.3 ± 11.8 years. Most patients were between 40 and 60 years of age. There were slightly more male patients than female patients. Hypertension and diabetes mellitus were commonly present among the study participants. Many patients had been on hemodialysis for more than six months at the time of enrollment.

Table 1: General Profile of the Study Participants (n = 138)

Variable	Findings
Mean age	46.3 ± 11.8 years
Age 25–39 years	21 cases
Age 40–60 years	83 cases
Age above 60 years	34 cases
Male patients	78
Female patients	60
Diabetes mellitus	63 cases
Hypertension	76 cases
Hemodialysis duration >6 months	89 cases

Most patients (82/138, 59.4%) had their catheter placed in the internal jugular vein The femoral vein was the second most commonly used site (41/138,29.7%), while the subclavian vein was used in fewer patients (15/138,10.8%).

Blood culture tests showed that Gram-positive bacteria were found more often than Gram-negative bacteria. Among all the germs, *Staphylococcus aureus* was found in the highest number of patients. *Staphylococcus epidermidis* was the second most common bacteria. Among Gram-negative bacteria, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* were also found in several patients. Other bacteria such as *Acinetobacter baumannii* and *Enterobacter cloacae* were found in smaller numbers.

Table 2: Microorganisms Recovered from Blood Culture Samples

Organism Identified	Number of Isolates
Staphylococcus aureus	42
Staphylococcus epidermidis	34
Klebsiella pneumoniae	17
Pseudomonas aeruginosa	14
Acinetobacter baumannii	11
Enterobacter cloacae	9
Other organisms	11

Antimicrobial susceptibility testing showed that **Vancomycin** and **Linezolid** were the most effective agents against Gram-positive isolates, particularly *Staphylococcus aureus* and *Staphylococcus epidermidis*. Among Gram-negative organisms, **Meropenem** and **Amikacin** demonstrated the highest susceptibility against *Klebsiella pneumoniae*, while **Piperacillin–Tazobactam** and **Meropenem** were the most active agents against *Pseudomonas aeruginosa*. All *Acinetobacter baumannii* isolates remained susceptible to **Colistin**, although several isolates exhibited multidrug resistance and resistance to Meropenem. Oxacillin-resistant *Staphylococcus aureus* and extended-spectrum β-lactamase (ESBL)-producing *Klebsiella pneumoniae* were also identified, indicating the presence of clinically significant antimicrobial resistance among the study isolates.

Table 3 summarizes the antimicrobial susceptibility profile of the predominant microorganisms isolated from patients with catheter-related bloodstream infections. Among the Gram-positive isolates, *Staphylococcus aureus* demonstrated the highest susceptibility to Vancomycin (95.2%) and Linezolid (92.9%), whereas Oxacillin resistance was observed in 35.7% of isolates. Similarly, *Staphylococcus epidermidis* showed excellent susceptibility to Vancomycin (97.1%) but a high rate of Penicillin resistance (61.8%).

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Among the Gram-negative organisms, *Klebsiella pneumoniae* was most susceptible to Meropenem (88.2%) and Amikacin (82.4%), although Ceftriaxone resistance was common (70.6%) and some isolates were identified as ESBL producers. *Pseudomonas aeruginosa* demonstrated the greatest susceptibility to Piperacillin–Tazobactam (85.7%) and Meropenem, while *Acinetobacter baumannii* remained completely susceptible to Colistin but exhibited considerable resistance to Meropenem (63.6%), with several multidrug-resistant isolates identified.

Table 3. Antimicrobial susceptibility profile of microorganisms isolated from patients with CRBSIs

Organism	Most sensitive antibiotics	Subsequent sensitive antibiotics	Major resistance pattern
Staphylococcus aureus	Vancomycin (95.2%)	Linezolid (92.9%), Clindamycin	Oxacillin resistance (35.7%)
Staphylococcus epidermidis	Vancomycin (97.1%)	Linezolid	Penicillin resistance (61.8%)
Klebsiella pneumoniae	Meropenem (88.2%)	Amikacin (82.4%)	Ceftriaxone resistance (70.6%); ESBL isolates
Pseudomonas aeruginosa	Piperacillin–Tazobactam (85.7%)	Meropenem	Reduced susceptibility to Ciprofloxacin (28.6%)
Acinetobacter baumannii	Colistin (100%)	–	Meropenem resistance (63.6%); MDR isolates

When the bacterial isolates were grouped according to Gram staining characteristics, Gram-positive bacteria accounted for the larger proportion of isolates (80/138,57.9%). Gram-negative organisms were also isolated in a considerable number of patients (58/138,42%).

Further observations showed that infections were more commonly seen in patients with diabetes mellitus and in those with prolonged catheter use. Patients having femoral vein catheterization also appeared to have a higher frequency of infections compared with patients using internal jugular access.

Discussion

Catheter-related bloodstream infections (CRBSIs) remain one of the major complications among patients receiving hemodialysis through vascular catheters. These infections contribute significantly to patient morbidity, prolonged hospital stay, increased treatment cost, and mortality. The present study was conducted to determine the microbial organism pattern and antimicrobial susceptibility profile in hemodialysis patients with CRBSIs (12, 13).

In the current study, the mean age of the patients was 46.3 ± 11.8 years, and most patients belonged to the 40–60 years age group. Similar findings have been reported in recent regional and international studies where middle-aged patients represented the majority of hemodialysis cases with catheter-related infections (12, 14). Male patients were slightly more common than female patients, which may be related to the higher prevalence of chronic kidney disease and vascular access procedures among males in the local population (14).

Hypertension and diabetes mellitus were common among study participants. Diabetes mellitus is believed to be an important risk factor for infections because impaired immune function and poor glycemic control increase susceptibility to bacterial colonization and bloodstream infections (15,

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16). Similarly, hypertension is frequently associated with chronic kidney disease and prolonged dependence on hemodialysis (15).

The internal jugular vein was the most commonly used catheter insertion site in the present study. This finding is comparable to recent studies where internal jugular access was preferred because of its lower risk of complications compared with femoral or subclavian access (16, 17). However, patients with femoral vein catheterization showed comparatively higher infection frequency. The increased risk of femoral access could be due to the difficulty in maintaining the cleanliness of the area and increased bacterial colonization around the catheter entry point (17).

Microbiological analysis revealed that CRBSIs were mainly caused by Gram-positive organisms and *Staphylococcus aureus* was the most common pathogen isolated followed by *Staphylococcus epidermidis*. These findings are consistent with recent studies reporting staphylococcal species as the predominant organisms responsible for catheter-related infections in hemodialysis patients (12, 18). The predominance of these organisms may be related to their presence as normal skin flora, which makes colonization of catheter surfaces during insertion or repeated manipulation easier (18).

Gram-negative organisms, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, were isolated from a large number of patients. Other organisms such as *Acinetobacter baumannii* and *Enterobacter cloacae* were also identified. The presence of these organisms indicates the increasing role of healthcare-associated pathogens in catheter-related infections (13, 16). Gram-negative infections are of clinical concern because many of these organisms have been associated with multidrug resistance and may lead to serious complications if not treated promptly (16).

The present study also showed that the majority of bloodstream infections were caused by Gram-positive bacteria while a relatively large proportion of isolates were Gram-negative organisms. Similar microbial patterns have been reported in recent studies of hemodialysis-related infections (12, 13). These findings underline the importance of adequate catheter care, hand hygiene, and infection control measures in order to reduce bacterial transmission and catheter-related bloodstream infections (17).

Our study found that the infection rate was higher in patients with prolonged catheter duration. Prolonged catheter use may allow bacteria to attach and form biofilms on catheter surfaces, increasing the risk of persistent bloodstream infections (18). In addition, diabetic patients appeared to have a higher frequency of infections compared with non-diabetic patients (15, 16). Femoral vein catheterization was also associated with increased infection burden when compared with internal jugular access (17).

The findings of the present study have important clinical implications. In addition to identifying the predominant microorganisms responsible for catheter-related bloodstream infections, antimicrobial susceptibility testing demonstrated high in vitro susceptibility of Vancomycin and Linezolid against Gram-positive isolates, whereas Meropenem, Amikacin, and Piperacillin–Tazobactam showed the highest activity against the majority of Gram-negative pathogens. The detection of Oxacillin-resistant *Staphylococcus aureus*, ESBL-producing *Klebsiella pneumoniae*, and multidrug-resistant *Acinetobacter baumannii* highlights the need for continuous antimicrobial resistance surveillance and regular review of empirical antibiotic policies

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in hemodialysis units. These findings may assist clinicians in selecting appropriate empirical antimicrobial therapy while awaiting culture and susceptibility results and support antimicrobial stewardship initiatives within the local healthcare setting (12, 18).

Conclusion

Catheter-related bloodstream infections remain a major cause of morbidity among patients undergoing hemodialysis. Gram-positive organisms, particularly *Staphylococcus aureus*, were the predominant pathogens, although Gram-negative bacteria also contributed substantially to the infection burden. Antimicrobial susceptibility testing demonstrated high in vitro susceptibility of Vancomycin and Linezolid against Gram-positive isolates and Meropenem, Amikacin, and Piperacillin–Tazobactam against most Gram-negative organisms, while multidrug-resistant isolates were also identified. These findings provide valuable local evidence to guide empirical antibiotic selection, strengthen antimicrobial stewardship, and improve infection control practices in hemodialysis units.

Study Limitations

This study has several limitations. First, it was conducted at a single tertiary care center, which may limit the generalizability of the findings to other healthcare settings. Second, the sample was restricted to patients undergoing hemodialysis with catheter-related bloodstream infections at one institution and may not fully represent the microbial spectrum observed in other regions. Third, although antimicrobial susceptibility testing was performed, molecular characterization of antimicrobial resistance mechanisms and long-term clinical outcomes were not evaluated. In addition, the study did not assess long-term clinical outcomes such as recurrent infections, catheter loss, hospitalization duration, or mortality associated with specific microbial isolates. These limitations should be considered while interpreting the findings of the study.

Future Recommendations

Further multicenter studies involving larger sample sizes are recommended to provide a more comprehensive understanding of the microbial profile of catheter-related bloodstream infections in hemodialysis patients. Future multicenter studies should evaluate molecular resistance mechanisms, multidrug-resistant organisms, antimicrobial stewardship interventions, and long-term clinical outcomes among hemodialysis patients with catheter-related bloodstream infections. Studies assessing the impact of catheter duration, vascular access type, infection prevention strategies, and long-term patient outcomes would further enhance understanding of CRBSIs. Continuous surveillance of local microbial trends is also recommended to strengthen infection control policies and improve patient care.

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CONTRIBUTION OF AUTHORS	
AUTHOR	**CONTRIBUTION**
Conception/Design	TA,SZ,MF,IU,FH,AK
Data acquisition, analysis and interpretation	SZ,AK
Manuscript writing and approval	MF,IU,FH
All the authors agree to take responsibility for every facet of the work, making sure that any concerns about its integrity or veracity are thoroughly examined and addressed.	