

Incidence, Microbiological Profile, Antimicrobial Resistance Patterns, and Risk Factors of Haemodialysis Catheter-Related Infections: A Prospective Observational Study

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Abstract

Background

Haemodialysis catheter-related infections (HCRI) are among the most frequent and serious complications in patients undergoing haemodialysis, contributing to increased morbidity, prolonged hospitalization, and inappropriate antimicrobial use. Understanding local microbiological patterns and associated risk factors is essential for optimizing management.

Objective

To assess the incidence of haemodialysis catheter-related infections, evaluate microbiological profile and antimicrobial utilization patterns, identify associated risk factors, assess clinical outcomes, and document drug information services provided by clinical pharmacists.

Methods

A six-month prospective observational study was conducted (October 2017–March 2018) in the nephrology department of a tertiary care hospital. Adult patients (≥ 18 years) with temporary haemodialysis catheters were enrolled and followed until discharge. Patients with pre-existing infections or major immunocompromising conditions were excluded. Incidence was calculated proportionately. Risk factors were analyzed using chi-square test and odds ratios. Microbiological and antibiotic sensitivity data were analyzed descriptively.

Results

Among 112 enrolled patients, 16 developed HCRI, yielding an incidence of 14.2%. *Escherichia coli* was the predominant organism identified. High resistance was observed against ceftriaxone, ciprofloxacin, and cefuroxime, while greater sensitivity was noted with tigecycline, colistin, and carbapenems. Vancomycin and amikacin were the most commonly prescribed antibiotics. Advanced age (≥ 60 years) (OR 3.15; $p = 0.036$) and ≥ 5 haemodialysis sessions (OR 9.08; $p < 0.001$) were strongly associated with infection development. Clinical recovery was achieved in 87.5% of infected patients. A total of eight drug information services were provided, primarily related to renal dose adjustments.

Conclusion

Haemodialysis catheter-related infections occurred in 14.2% of patients, with Gram-negative organisms predominating and notable resistance to commonly used antibiotics. Advanced age and increased

dialysis exposure were significant risk factors. Culture-guided therapy and pharmacist-supported dose optimization may improve patient outcomes and promote rational antimicrobial use.

INTRODUCTION

Chronic Kidney Disease (CKD) is a condition where the kidneys do not function or maintain their normal structure properly for at least three months or longer¹ with pessimistic involvement of health. CKD is recognised as a significant global health problem.² From 1990 to 2013, age-adjusted death rates due to chronic kidney disease (CKD) rose by 36.9% across 188 countries, making it the 19th leading cause of years of life lost. The prevalence of CKD increases with age, affecting nearly 30% of individuals above 70 years. In the early 2000s, a new classification system for kidney disease was introduced, which included both glomerular filtration rate (GFR) and albuminuria as key parameters. The Kidney Disease: Improving Global Outcomes (KDIGO) guidelines were later developed to standardize the evaluation and management of CKD, classified CKD as six stages based on GFR from Normal or high kidney function with GFR greater than or equal to 90ml/min to Kidney failure with GFR less than or equal to 15ml/min.¹

These infections occur when bacteria enter the bloodstream through an intravenous catheter. It is among the most commonly observed, serious, life-threatening, and expensive complications of central venous catheterization and also the most common cause of nosocomial bacteraemia. Since infections occur more frequently with catheters than with AV fistulas (AVF) or AV grafts (AVG), prioritizing preventive care is essential. Preventive care involves reducing the use and duration of catheters, proper disinfection, and sterile techniques and usage of an anti-microbial ointment at the exit site.⁴ The National Kidney Foundation-Dialysis Outcomes Quality Initiative (NKF-DOQI) guidelines suggest that temporary catheters can be left at the femoral vein for only 5 days, while for internal jugular and subclavian sites, the duration is 21 days each, as these are based on the cumulative risk of bacteremia.⁵

Still, in contrast to patient's pursuing a home therapy for renal replacement, most of them choose to start haemodialysis via a dialysis catheter and have a longer duration of dialysis catheter use because of the logistic and physiologic challenges involved in AVF development and maturation.⁶ Patients undergoing haemodialysis are recognized to have a higher risk of bacteremia. A number of different things can raise the risk of infection. This includes the main disease, the uremic state, and the dialysis method itself.⁷ The presence of fever or chills is the most frequent clinical symptom, and these features are linked to positive blood cultures in 60% to 80% of patients and the other symptoms that could be present are hemodynamic instability, change of mental status, catheter malfunction, hypothermia, nausea/vomiting, and feeling tired or ill generally.⁸ Catheter-related infections have a significant economic and clinical impact in haemodialysis patients and several studies have measured it.⁹ Compared to the general population, the risk of sepsis-related death in dialysis patients is 100 times higher, and infection-related, as well as all-cause mortality, is at its highest in those with catheters.⁵ The study was done to find out how often haemodialysis catheter related infections happened and what was done to prevent and

properly treat these infections in dialysis patients by identifying the causative micro-organism as it is important in improving patient care, decreasing costs and complications.

METHODOLOGY

Study design

The study took place in the nephrology department of a university hospital. It was a hospital-based prospective observational study and was done over a six-month period (October 2017 to March 2018). The Institutional Human Ethics Committee of JSS College of Pharmacy, Mysore, Karnataka gave their approval for the study to be conducted.

Study Criteria:

All admitted patients with a temporary catheter inserted for carrying out haemodialysis were included in the study. Patients with indwelling catheters of any type were excluded from the study other than haemodialysis because our primary concern was only haemodialysis catheter related infections. Patient's whose catheters are removed due to complications other than catheter related infections and patients with known diagnosis of Sepsis, Severe liver disease, Cancer, Tuberculosis, HIV, Hepatitis B and on immunosuppressants or patients with documented diagnosis of infection within 15 days prior to inclusion of the study were also excluded.

Study Procedure:

Patients who visited or were admitted to the nephrology department were screened, and those meeting the study criteria were enrolled after providing informed consent. The relevant and necessary data were mainly collected through patient case sheets, patient treatment charts and medical records, discussion with patient and caretakers, communication with other health care professionals and other relevant sources like hospital database. Of the 537 patients reviewed, 112 patients met the study criteria and were followed till discharge. Among the 112 patients, 16 of them developed Haemodialysis Catheter related Infections (HCRI) which was categorized as the infection group and the remaining 96 patients in the non-infection group. Inpatient case sheets of patients enrolled were reviewed on daily basis. All the relevant information like the demographic details, past medical history, allergic status, diagnosis, lab investigations, management, duration of therapy and the results were gathered and recorded on a specifically designed data collection form.

For study purpose Catheter related infections were defined as patients presenting with persistent fever and/or positive blood culture reports along with 1 or more of following symptoms after catheter insertion: Chills, Hypotension, Breathlessness, Cough, Nausea/Vomiting, Generalised malaise. The

various management strategies for catheter related infections and its outcome in each patient were recorded until discharge.

Data Analysis:

All the enrolled patients were grouped according to their age, gender, primary diagnosis, number of haemodialysis, type of catheter (jugular or femoral), number of days in hospital and was reported in means and percentages. Antibiotics used were reported in numbers and percentages. Outcomes were measured as number of patients recovered (as assessed by freedom from symptoms and completion of antibiotic course without symptom recurrence) or outcome unknown due to patients discharged against medical advice. Catheter-related infection rates in patients undergoing haemodialysis was calculated by taking the number of patients who developed HCRI as numerator and with the total number of enrolled patients as the denominator. Association of risk factors with occurrence of infection and their significance was assessed using chi square.

RESULTS

Demographics

Of the 537 patients reviewed, 112 patients met the study criteria and were then monitored till discharge. Among the 112 patients, 16 of them developed Haemodialysis Catheter related Infections (HCRI) which was categorised as the infection group and the remaining 96 patients in the non-infection group. The demographic details of both the groups are given in Table 1.

Among the patients without infection, 68 (70.8%) were male and 28 (29.2%) were female and 12 (75%) of them were males and 4 (25%) females in the infection group. The mean age of patients was 49.3 ± 13.09 years in the non-infection group and 54 ± 15.01 years in the infection group. Majority of the study subjects in non-infection fell within the age group 40–49 years (28.1%) and 50–59 years (28.1%), followed by 30–39 years (16.6%) whereas majority of the study subjects in the infection group belonged to the age group 60–69 years (37.5%), with the next highest proportion in the 50–59 years group (31.25%)

Table 1
Demographics of Infected and Non-infection Group

Demographic details	Non-Infected Group		Infected Group	
	No. of Patients	Percentage	No. of Patients	Percentage
	(n = 96)		(n = 16)	
Age (in years)				
18–29	6	6.25	2	12.5
30–39	16	16.66	1	6.25
40–49	27	28.12	1	6.25
50–59	27	28.12	5	31.25
60–69	13	13.54	6	37.5
70–79	7	7.29	1	6.25
Gender				
Male	68	70.8	12	75
Female	28	29.2	4	25
Primary diagnosis				
Acute on CKD	81	84.38	15	93.75
AKI	11	11.46	1	6.25
Others (Snake bite, IgA Nephropathy, Renal Artery Stenosis)	4	4.16	0	
Avg no. of haemodialysis sessions	4.24+/-1.9		9.5+/-8.23	
Type of catheter				
Jugular	96	100	16	100
Femoral	0	0	0	0
No of days in hospital	9.22+/-4.18		10.5+/-6.75	

Incidence of HCRI: Among the 112 patients, 16 of them developed HCRI. The incidence was calculated using the formula

Incidence of HCRI = No. of patients who developed the HCRI / Total no. of patients enrolled in the study which was analysed and found to be 14.2%.

Pattern of Management: The three potential management options for HCRI, that were followed among the 16 patients were (1) treatment with antibiotics alone, (2) treatment with antibiotics along with change in the catheter site and (3) treatment with antibiotics along with early catheter removal with delayed insertion of a new catheter. The data regarding the various management options is given in Table 2. According to our study, it was observed that there was a change in the catheter site in 3 patients of which 2 patients had a replacement of jugular catheter by femoral catheter and creation of Arteriovenous Fistula (AVF) in the remaining one.

Table 2
Management Options

Management Options	No. of Patients (n = 16)	Percentage
Treatment with antibiotics alone	7	43.75
Treatment with antibiotics along with change in the catheter site	3	18.75
Treatment with antibiotics along with early catheter removal and delayed reinsertionplacement of a new catheter	6	37.5

Causative Organism: From the study population, it was observed that culture sensitivity tests were performed for 9 patients, wherein the most prominent causative organism was Escherichia coli (E. coli), identified in 6 patients. The antimicrobial susceptibility patterns of the isolated microorganisms are presented in Table 3. The detailed antibiotic susceptibility profile of E. coli is presented in Table 4, while the corresponding antibiotic resistance profile is presented in Table 5.

Table 3
Sensitivity pattern

Causative Organism	Sensitive Drugs	Resistant Drugs
E. coli	Imipenem, Meropenem, Tigecycline, Colistin, Nitrofurantoin, Ertapenem	Cefipime, Ciprofloxacin, Gentamicin, Piperacillin Tazobactam, Cefoperazone Sulbactam, Cefuroxime, Sulphamethaxazole Trimethoprim, Amikacin, Ampicillin, Ceftriaxone, Cefuroxime Axetil, Nalidixic Acid, amoxicillin+clavulanic acid
	Cefipime, Imipenem, Meropenem, Piperacillin Tazobactam, Tigecycline, Colistin, Cefoperazone Sulbactam, Sulphamethaxazole Trimethoprim, Amikacin, nitrofurantoin, Ertapenem	Ciprofloxacin, Gentamicin, Cefuroxime, Ampicillin, Ceftriaxone, Cefuroxime Axetil, Nalidixic Acid, Amoxicillin/clavulanic acid
	Imipenem, Meropenem, Piperacillin Tazobactam, Tigecycline, Colistin, Cefoperazone Sulbactam, Amikacin, Ertapenem	Cefipime, Ciprofloxacin, Gentamicin, Cefuroxime, Sulphamethaxazole Trimethoprim, Ampicillin, Ceftriaxone, Cefuroxime Axetil, Nalidixic Acid
	Imipenem, Meropenem, Piperacillin Tazobactam, Tigecycline, Colistin, Cefoperazone Sulbactam, Amikacin, Nitrofurantoin, Ertapenem	Cefipime, Ciprofloxacin, Gentamicin, Cefuroxime, Sulphamethaxazole Trimethoprim, Ampicillin, Ceftriaxone, Cefuroxime Axetil, Amoxicillin/clavulanic acid
	Gentamicin, Imipenem, Meropenem, Tigecycline, Colistin, Amikacin, Ertapenem	Ciprofloxacin, Piperacillin Tazobactam, Ampicillin, Ceftriaxone, Cefoperazone+Sulbactam, Cefuroxime, Sulphamethaxazole Trimethoprim, Cefuroxime Axetil, Nalidixic Acid, Amoxicillin+Clavulanic acid
	Tigecycline, Colistin, Nitrofurantoin	Cefipime, Ciprofloxacin, Gentamicin, Imipenem, Meropenem, Piperacillin Tazobactam, Cefoperazone Sulbactam, Sulphamethaxazole Trimethoprim, Amikacin, Ampicillin, Ceftriaxone, Cefuroxime Axetil, Nalidixic Acid, Amoxicillin/ Clavulanic acid
Staphylococcus haemolyticus	Tigecycline, Daptomycin, Rifampicin, Teicoplanin, Tetracycline, Vancomycin, Linezolid, Nitrofurantoin	Ciprofloxacin, Gentamicin, Levofloxacin, Erythromycin, Oxacillin, Clindamycin
Enterococci	Linezolid, Vancomycin Nitrofurantoin	Ciprofloxacin, Gentamicin, Tetracycline, Penicillin G
Methicillin Resistant	Gentamicin, Tigecycline, Sulphamethaxazole	Ciprofloxacin, Oxacillin

Causative Organism	Sensitive Drugs	Resistant Drugs
Staphylococcus aureus (MRSA)	Trimethoprim, Linezolid, Nitrofurantoin, Rifampicin, Teicoplanin, Tetracycline, Clindamycin, Daptomycin, Erythromycin	

Table 4
Sensistivity of Antibiotics towards *E. coli*

Name of the Drug	No. of Patients (n = 6)	Percentage
Tigecycline	6	100
Colistin	6	100
Imepenem	5	83.3
Meropenem	5	83.3
Ertapenem	5	83.3
Amikacin	4	66.6
Nitrofurantoin	4	66.6
Cefoperazone+Sulbactam	3	50
Piperacillin+Tazobactam	3	50
Cefipime	1	16.6
Sulphamethoxazole+Trimethoprim	1	16.6

Table 5
Resistance of Antibiotics towards *E. coli*

Name of the Drug	No. of Patients (n = 6)	Percentage
Ciprofloxacin	6	100
Ceftriaxone	6	100
Cefuroxime Axetil	6	100
Ampicillin	6	100
Cefuroxime	5	83.3
Sulphamethoxazole+Trimethoprim	5	83.3
Nalidixic acid	5	83.3
Amoxizillin+Clavulanate	5	83.3
Gentamicin	5	83.3
Cefipime	4	66.6
Piperacillin+Tazobactam	3	50
Cefoperazone+Sulbactam	3	50
Amikacin	2	33.3

Antibiotic Therapy: All the 16 patients with infections received antibiotics as either mono, dual, triple or quintet therapy. Among these patients, 7 of them received dual antibiotic therapy (43.75%) of which the commonly used combination was Vancomycin with Amikacin (57.1%) in 4 patients. The amount of antibiotics given to patients are presented in Table 6.

Table 6
Number of antibiotics prescribed

No. of Antibiotics	No. of Patients	Percentage	Antibiotics
Mono therapy	3	18.75%	• Cefoperazone+sulbactum (1) • Vancomycin (1) • Ceftriaxone (1)
Dual therapy	7	43.75%	• Vancomycin, Meropenem (1) • Vancomycin, Amikacin (4) • Faropenem, Imepenen(1) • Ceftriaxone, Amikacin (1)
Triple therapy	5	31.25%	• Amikacin, Cefixime, Vancomycin (1) • Cefoperazone+ sulbactum, Levofloxacin, Cefixime (1) • Piperacillin+Tazobactum, Levofloxacin, Ceftriaxone (1) • Amikacin, Vancomycin, Cefoperazone+sulbactum (1) • Cefoperazone+sulbactum, Piperacillin+Tazobactum, Amikacin (1)
Quintet therapy	1	6.25%	• Amikacin, Meropenem, Vancomycin, Piperacillin+Tazobactum, Metronidazole. (1)

Prescribing Frequency of Antibiotics: All the infected patients were prescribed with antibiotics under 11 different classes. Vancomycin [n = 9 (56.25%)] and Amikacin [n = 9 (56.25%)] were the most commonly prescribed antibiotics.

Outcomes of Management: As per the study by Krishnasami Z et.al outcome of management of HCRI was clinical cure defined as lack of fever/chills and normalization of blood pressure by 48 hrs, or post treatment surveillance blood cultures being negative.¹⁰ Hence in our study outcomes of management was primarily based on the patient disease and health status and was defined as either recovered (as assessed by freedom from symptoms and completion of antibiotic course without symptom recurrence) or outcome unknown due to patients discharged against medical advice. The number of patients recovered was found to be 14 (87.5%) and the outcome unknown was 2 (12.5%).

Risk factors: Hemodialysis catheter-related infections (HCRI) are a major contributor to increased mortality, morbidity, and treatment costs in patients undergoing hemodialysis. Preventing HCRI depends on identifying the underlying risk factors that predispose patients to infection.¹¹ To assess the

association of risk factors with the development of HCRI, we compared the infection group (n = 16) versus non-infection group (n = 96) using chi-square test. The relationship between risk factors and the occurrence of HCRI is discussed in Table 7.

Table 7
Association of HCRI with various factors

Factors	Non-infection group (n = 96)	Infection group (n = 16)	Chi-square value	p-value	Odds ratio (OR) (95%CI)
Gender	68	12	0.117	0.733	1.235(0.365, 4.16)
Male	28	4			
Female					
Age (years)	19	7	4.416	0.036	3.152 (1.041, 9.54)
≥ 60	77	9			
18–60					
No. of HD	65	3	13.782	0.000	9.086 (2.412, 34.22)
< 5	31	13			
≥ 5					
CLcr	66	7	3.777	0.052	2.289 (0.963, 8.312)
< 10	30	9			
≥ 10					
Diabetes Mellitus (DM)	45	8	0.054	0.817	0.882 (0.306, 2.544)
With DM	51	8			
Without DM					
Hemoglobin	86	15	0.269	0.604	0.537 (0.068, 4.813)
< 12	10	1			
≥ 12					

In our study age and number of haemodialysis sessions were found to have a significant association with the development of HCRI whereas the other factors such as gender, creatinine clearance, diabetes mellitus, and hemoglobin with HCRI did not have any association.

Drug Information Services: Clinical pharmacist service to provide and document drug information (DI) services to the health care professionals on various drug related aspects of haemodialysis catheter

related infections were also an objective of our study. Among the 16 patients with HCRI, a total of 8 DI for better patient care was provided to the respective nephrologist on request. The DI was categorized as: 1) Incidence of adverse drug reactions (ADR), 2) Dosage adjustments, 3) Selection of drug, 4) Drug safety and monitoring parameters. Among these, DI on dosage adjustment [n = 4 (50%)] were the most common ones. The data of DI services provided has been depicted in Table 8.

Table 8
Drug information services

DI services	Number of DI provided	Percentage	Description
Incidence of ADR	2	25%	• Ototoxicity with amikacin (1–10%) • Acute interstitial nephritis with levofloxacin (0.2–1.3%)
Dosage adjustments	4	50%	• Levofloxacin: 500mg initially then 250mg everyday (GFR:10-19ml/min) • Imepenenem: 250mg IV Q12H (GFR:<20ml/min) • Meropenem: 500mg IV Q24H (GFR: <10ml/min), 500mg IV Q12H (GFR:10-25ml/min) • Vancomycin: 500mg IV Q24-48H or 1g IV Q48-96H (GFR:10-50ml/min), 500mg IV Q48H (GFR:<10ml/min)
Selection of drug	1	12.5%	Antibiotic selection (Meropenem or Imepenenem)
Drug safety and monitoring	1	12.5%	Safety of VitD3 in ESRD patients

DISCUSSION

In this study, the demographic profile of the patients indicates a predominance of males. According to the study conducted by Nabi Z et.al, the mean ages of the patients with HCRI was higher than the non-infected group, however the difference was not statistically significant.⁷ As per the same study majority of the study subjects in the non-infected and the infected group belonged to the 41–60 years age group, with the next highest proportion in the 61–80 years age group which was similar to the findings of our study. Unlike other studies that determined the duration of catheter use, our study identified the mean number of dialysis sessions in both the groups as it is one of the risk factors for the development of HCRI and was found as 4.24 ± 1.9 and 9.5 ± 8.23 respectively. The temporary haemodialysis catheter was placed in the jugular vein in all the enrolled patients in both the infection and non-infection groups. In various studies, higher incidence of catheter related infections occurred with femoral access^{12,13} and in some it was higher with jugular access.^{14,15} In our study we had only two patients with femoral access

that too which was changed from jugular to femoral during the management of HCRI. The study also showed a slight increase in the length of hospital stay from non-infection to infection group.

According to the literature, 1% to 13% of patients with haemodialysis catheter develop catheter related infections.^{12,13} Our rates were near to this upper limit were 14.2% of the patients with haemodialysis catheters often developed catheter-related infections. These infections may be caused by a wide spectrum of Gram-positive and Gram-negative bacteria. In these cases, initiating antibiotic treatment is usually done based on the doctor's educated guess.

Selecting the first antibiotics should be based on patient's condition, how severe it is, risk factors for infection, and which pathogens are usually associated with the specific intravascular device being used. Once empiric therapy is initiated, it is critical to quickly check culture and sensitivity results to direct subsequent treatments.⁸ When organism and sensitivity results are available, the antibiotic regimen should be modified accordingly.¹⁸ Once the empirical antibiotic therapy is initiated, culture sensitivity data plays a crucial role in selecting the appropriate antibiotics for the management of HCRI.

Although Colistin became available for use in clinical practice during the 1960s, its widespread use declined due to the emergence of reports of serious adverse events in the medical community¹⁹. Nowadays it has gained popularity clinically, the rise of multidrug-resistant Gram-negative bacteria exposed a major problem which had to be dealt with very few new antibiotics being developed. Hence, intravenous colistin has come out as a safe and potent drug for the treatment of infections caused by these resistant bacteria.²¹ Our study reflected sensitive patterns of Colistin towards the organism's causing infection in the patients. The findings of a study by Krishnasami Z et.al²² concluded that empiric treatment with broad-spectrum antibiotics, such as vancomycin and gentamicin, should be started immediately after obtaining blood cultures, since both Gram-positive and Gram-negative organisms are commonly isolated from these samples.²³

In our study, the treatment given for HCRI was in concordance with the Infectious Diseases Society of America (IDSA) guidelines. As per IDSA guideline, Vancomycin is generally preferred in settings where the prevalence of MRSA is high. In cases where MRSA is not a concern, penicillinase-resistant penicillins such as nafcillin or oxacillin are recommended. Complicated HCRI caused by gram-positive bacteria requires antibiotic therapy for 4–6 weeks and uncomplicated HCRI requires antibiotic course of 14 days.¹⁷ For Gram-negative bacilli, including *Pseudomonas aeruginosa*, 3rd or 4th generation cephalosporins such as ceftazidime or cefepime can be used. HCRI caused by gram-negative bacteria requires 10–14 days of antibiotic treatment. However, final decision on specific antibiotic agents is dependent on final blood culture result and sensitivities, and whether or not patient has any allergies.²⁴

Risk Factors: Some studies have shown that older age, identified as a significant factor associated with severe catheter-related infection, is linked to immunosuppression, increased susceptibility to infection, and a higher risk of adverse outcomes, including sepsis.²⁵ This finding is similar to our study where we classified all the patients into two groups based on age as elderly (≥ 60 years) and adults (18–60 years).

On statistical analysis it was found significant that elderly patients had a 2.15-fold (Odds ratio [OR]: 3.152, 95% confidence interval [CI]: 1.041–9.545, $p < 0.05$) increased chance of developing HCRI compared with adults. However, there were no fatal outcomes in the patients from our study. Other studies^{5,26}, have determined the association of HCRI with duration of catheter residing in the body, we assessed the risk of HCRI with the number of haemodialysis sessions. For this purpose, we classified all the patients into two groups based on number of haemodialysis sessions that the patient received: <5 HD sessions and ≥ 5 HD sessions. It was found that patients who received ≥ 5 HD sessions had an 8.08-fold (OR: 9.086, 95% CI: 2.412–34.227, $p < 0.05$) increased chance of developing HCRI compared with patients who received < 5 HD sessions and this was statistically significant. According to the study conducted by Lemaire et al., it was confirmed that prolonged catheter use (≥ 10 days) was strongly related with the risk of HCRI.²⁷ Since the number of HD sessions is an indirect measure of duration of catheter usage, association of number of HD session with HCRI was assessed.

Since many antibiotics are excreted renally they require dosage adjustments based on individual creatinine clearance even for patients falling in the same GFR ranges because different drugs act differently in each patient²⁸. Clinical pharmacist services can also be extended to determine serum drug concentration which could be adopted to individualise the dose in each patients²⁹. As per the study by Bond CA et.al pharmacist-led therapeutic drug monitoring for vancomycin and aminoglycoside therapy is widely practiced in the United States. In fact, data from 2006 show that around 64.4% and 63.8% of surveyed hospitals provided this service for aminoglycosides and vancomycin, respectively, reflecting how routinely these drugs are managed in clinical settings.³⁰

LIMITATIONS

- The study was carried out in a single tertiary care center with a relatively small sample size, which, in a way, may limit how far the findings can be generalized to a broader population.
- The study duration was limited to six months, and seasonal variations in infection patterns could not be assessed.
- The incidence of infection was calculated based on number of patients rather than catheter-days, which may not accurately reflect true infection rates.
- Microbiological data were available only for a subset of patients, which may limit the interpretation of pathogen distribution and antimicrobial resistance patterns.

CONCLUSION

Catheter related infections occurred at a rate of 14.2% in haemodialysis patients. There has been a noticeable increase in the incidence of Gram-negative infections highlighted in this study. Resistance to ceftriaxone, ciprofloxacin and cefuroxime axetil amongst gram -ve is also a concerning trend. There is a greater need for culture sensitivity tests, in order to prevent inappropriate antibiotic use, antibiotic resistance and reduce the cost of the treatment associated with use of antibiotics. The most commonly

prescribed antibiotics for HCRI were vancomycin and amikacin as per this study. Majority of the patients completed the treatment successfully without recurrence of infection until discharge. Advancement in age and increase in the number of haemodialysis sessions are the major risk factors related to infections in haemodialysis patients. Drug information services on various drug related aspects for better patient care were provided of which dose adjustments were a majority.

Abbreviations

Abbreviation	Full Form
CKD	Chronic Kidney Disease
KDIGO	Kidney Disease: Improving Global Outcomes
GFR	Glomerular Filtration Rate
HCRI	Hemodialysis Catheter-Related Infection
HD	Hemodialysis
AVF	Arteriovenous Fistula
AVG	Arteriovenous Graft
NKF-DOQI	National Kidney Foundation–Dialysis Outcomes Quality Initiative
AKI	Acute Kidney Injury
IgA	Immunoglobulin A
OR	Odds Ratio
CI	Confidence Interval
DM	Diabetes Mellitus
CLcr	Creatinine Clearance
MRSA	Methicillin-Resistant <i>Staphylococcus aureus</i>
IDSA	Infectious Diseases Society of America
ADR	Adverse Drug Reaction
ESRD	End-Stage Renal Disease

Declarations

Ethics approval and consent to participate

The study was approved by the Institutional Ethics Committee, JSS Medical College, JSS Academy of Higher Education & Research, Mysuru, Karnataka, India (Approval No: IEC/JSSCPM/17-18/001) Written

informed consent was obtained from all participants before their enrolment in the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Shruthi Shibu: Conceptualization, data collection, data analysis, manuscript drafting.

Sunil Kumar S: Data analysis, literature review, manuscript writing, and editing.

Dr. Manjunath S. Shetty: Clinical supervision, data interpretation, manuscript review.

Dr. Kiran K. K.: Clinical guidance, data interpretation, manuscript review.

Dr. Savitha R. S: Study supervision, methodology, manuscript review, and final approval.

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