Original Article

Association of Prescription Pattern and Antimicrobial Sensitivity Pattern of Catheter Related Infection in Patients Undergoing Dialysis

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ABSTRACT

Background: Catheter-related infections (CRIs) are a major complication in hemodialysis patients, particularly those dependent on central venous catheters. These infections increase morbidity, mortality, and healthcare costs, while also driving antimicrobial resistance. In India, where a large proportion of patients initiate dialysis with catheters, CRIs are highly prevalent. However, there is limited evidence linking prescription practices with antimicrobial sensitivity patterns in this population.

Methods: This prospective, observational study was conducted over 12 months in the dialysis unit of a tertiary care teaching hospital in India. Adult patients with end-stage renal disease undergoing maintenance hemodialysis through central venous catheters who developed suspected or confirmed CRIs were enrolled (n=120). Clinical evaluation, blood and catheter tip cultures, and antimicrobial susceptibility testing were performed according to CLSI guidelines. Prescription patterns of empirical and culture-guided therapy were documented and analyzed for appropriateness.

Results: The incidence of CRI was 1.3 per 100 patient-months. The mean age of patients was 58.8 years, with diabetic kidney disease being the leading cause of ESRD (45%). Gram-positive organisms predominated, with Coagulase-Negative Staphylococci (40.8%) and Staphylococcus aureus (29.2%) as the most frequent pathogens, while gram-negative bacilli were less common. Empirical therapy was dominated by vancomycin-based regimens, with culture results prompting a shift toward vancomycin monotherapy (25.8% to 38.3%). MDROs were identified in 73.3% of cases and were significantly associated with higher recurrence rates (42.0% vs. 19.1%, p=0.0108).

Conclusion: This study demonstrates a high burden of CRIs in Indian hemodialysis patients, predominantly caused by gram-positive organisms, with vancomycin forming the cornerstone of therapy. The strong association between MDROs and recurrence underscores the urgent need for antimicrobial stewardship and preventive strategies, including antimicrobial lock solutions, to reduce recurrence and improve outcomes.

Keywords: Catheter-related infections; Hemodialysis; Antimicrobial resistance; Multidrug-resistant organisms; Prescription patterns.

INTRODUCTION

Catheter-related infections (CRIs) remain one of the most significant complications in patients undergoing dialysis, particularly those dependent on central venous catheters (CVCs) for vascular access.[1] While arteriovenous fistulas are considered the gold standard for long-term hemodialysis, limited vascular access, delayed maturation, and patient comorbidities often necessitate the use of catheters.[2] Unfortunately, catheters are inherently prone to colonization by microorganisms due to biofilm formation, repeated handling, and prolonged indwelling time. These infections not only increase morbidity and mortality but also contribute to prolonged hospital stays, higher healthcare costs, and the emergence of multidrug-resistant organisms.[3] The choice of empirical antimicrobial therapy is often guided by local sensitivity patterns, yet inappropriate or indiscriminate prescription practices can further exacerbate resistance. Understanding the interplay between prescription patterns and antimicrobial sensitivity is therefore critical to optimizing patient outcomes and preserving the efficacy of available drugs.

In India, the burden of end-stage renal disease (ESRD) is rising steadily, driven by the increasing prevalence of diabetes mellitus, hypertension, and other chronic kidney diseases. Estimates suggest that nearly 200,000 new patients require renal replacement therapy annually, with hemodialysis being the most common modality.[4] Due to infrastructural and socioeconomic constraints, a large proportion of Indian patients initiate dialysis with catheters rather than fistulas. Consequently, CRIs are highly prevalent in this population, with reported incidence rates ranging from 2 to 5 episodes per 1,000 catheter-days. Gram-positive organisms, particularly *Staphylococcus aureus* and coagulase-negative staphylococci, dominate the microbiological spectrum, though Gram-negative bacilli and fungal pathogens are increasingly reported.[5-9]

The relationship between prescription patterns and antimicrobial sensitivity is central to the management of

CRIs. Empirical therapy is often initiated before culture results are available, and the choice of agents reflects both physician preference and institutional protocols. However, inappropriate empirical coverage, prolonged use of broad-spectrum antibiotics, and inadequate de-escalation contribute to resistance. Conversely, resistance patterns influence prescribing behavior, creating a feedback loop that can either improve or worsen outcomes depending on stewardship practices.

Several international studies have documented the microbiological profile of CRIs and highlighted the growing challenge of antimicrobial resistance. Evidence suggests that methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and extended-spectrum beta-lactamase (ESBL)-producing Gram-negative bacilli are increasingly implicated in catheter-related bloodstream infections.[10, 11] In India, smaller single-center studies have reported similar trends, with high resistance rates to commonly used agents such as cephalosporins, fluoroquinolones, and aminoglycosides.

Despite the high burden of CRIs in Indian dialysis patients, there is a paucity of comprehensive studies examining the association between prescription patterns and antimicrobial sensitivity. Existing literature often focuses either on microbiological profiles or on clinical outcomes, without integrating prescribing practices into the analysis. Moreover, regional variations in microbial flora and resistance trends are poorly captured, limiting the generalizability of findings. There is also limited evidence on how empirical therapy aligns with culture results and whether prescribing practices contribute to resistance development in this vulnerable population. Addressing these gaps is crucial for informing antimicrobial stewardship programs, guiding empirical therapy, and ultimately reducing morbidity and mortality in dialysis patients.

The present study seeks to address the research question: *What is the association between prescription patterns and antimicrobial sensitivity patterns of catheter-related infections in patients undergoing dialysis in the Indian population?* It is hypothesized that inappropriate or empirically broad-spectrum prescribing practices are significantly associated with higher antimicrobial resistance rates and adverse clinical outcomes in this group. Accordingly, the objectives of the study are to systematically analyze the prescription patterns used in the management of catheter-related infections, to determine the antimicrobial sensitivity profiles of the causative organisms, and to evaluate the relationship between prescribing behavior and resistance trends, thereby generating evidence to inform rational antimicrobial use and strengthen stewardship strategies in dialysis care.

MATERIALS AND METHODS

Study Overview: This was a prospective, observational study conducted in the dialysis unit of a tertiary care teaching hospital in India over a period of 12 months. The study was designed to evaluate the association between prescription patterns and antimicrobial sensitivity patterns in patients who developed catheter-related infections (CRIs) while undergoing hemodialysis. All patients meeting the inclusion criteria and providing informed consent were enrolled consecutively. Ethical clearance was obtained from the Institutional Ethics Committee prior to initiation.

Study Population: The study population included adult patients (≥18 years) with end-stage renal disease (ESRD) undergoing maintenance hemodialysis through central venous catheters (tunneled or non-tunneled) who developed suspected or confirmed catheter-related infections.

Inclusion criteria: Patients with ESRD on hemodialysis with clinical suspicion of CRI (fever, chills, catheter site erythema, purulent discharge, or unexplained bacteremia).

Exclusion criteria: Patients with arteriovenous fistula or graft as primary access or patients already on long-term suppressive antibiotic therapy.

Sample Size: The sample size was calculated based on the expected prevalence of CRIs in the dialysis population and the anticipated proportion of resistant isolates. Assuming a prevalence of 20% and a 95% confidence level with 5% margin of error, the minimum required sample size was estimated at approximately 120 patients.

Outcome Parameters

- **Primary outcomes:**
  - Microbiological profile and antimicrobial sensitivity pattern of organisms isolated from catheter-related infections.
  - Prescription patterns of empirical and definitive antimicrobial therapy.
  - Association between prescription practices and resistance trends.
- **Secondary outcomes:**
  - Clinical outcomes including resolution of infection, recurrence, hospitalization duration, and mortality.
  - Concordance between empirical therapy and culture-directed therapy.

Methodology

1. **Clinical evaluation:** Patients presenting with suspected CRI underwent detailed clinical assessment and documentation of symptoms, comorbidities, and catheter characteristics.
2. **Sample collection:** Blood cultures (peripheral and catheter-drawn) and catheter tip cultures (where removal was indicated) were obtained under aseptic precautions.
3. **Microbiological analysis:** Samples were processed in the microbiology laboratory using standard culture techniques. Organisms were identified, and

antimicrobial susceptibility testing was performed according to Clinical and Laboratory Standards Institute (CLSI) guidelines.[12] Multi-Drug-Resistant Organisms (MDROs) were defined as those resistant to at least one agent in three or more antimicrobial categories.[13]

4. **Prescription pattern assessment:** Details of empirical antibiotic therapy, dose, duration, and subsequent modifications based on culture results were recorded. Prescriptions were categorized as appropriate or inappropriate based on alignment with sensitivity results and institutional guidelines.
5. **Follow-up:** Patients were followed until resolution of infection, catheter removal, or death. Clinical outcomes and recurrence were documented.

Statistical Analysis

Data were entered into a secure database and analyzed using **Graph Pad Version 8.4.3**. Frequencies, percentages, means, and standard deviations were used to summarize demographic, clinical, and microbiological data. Fisher's exact test was applied for categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 120 cases of CRI occurred during the study period, with an incidence rate of 1.3 infections per 100 patient-months. The baseline demographic and clinical characteristics of the 120 patients who developed catheter-related infections (CRI) reveal a predominantly male cohort (59.17%) with a mean age of approximately 59 years. Patients had been on hemodialysis for an average of about 31 months, indicating a substantial duration of dialysis exposure prior to infection. The leading cause of end-stage renal disease (ESRD) was diabetic kidney disease (45%), followed by chronic glomerulonephritis, lupus nephritis, obstructive uropathy, and hypertension, suggesting that diabetes is a significant comorbidity in this population [Table 1].

Table 1: Distribution of Patients with CRI with respect to Baseline Demographic and Clinical Characteristics

Parameters	Statistics (N=120)
Age in Years, Mean ± SD	58.79 ± 9.56
Male Gender, n (%)	71 (59.17)
Time of Haemodialysis in Months, Mean ± SD	31.29 ± 16.72
Primary Cause of ESRD, n (%)	
Diabetic Kidney Disease	54 (45)
Chronic glomerulonephritis	20 (16.67)
Lupus nephritis	17 (14.17)
Obstructive uropathy	16 (13.33)
Hypertension	13 (10.83)

The distribution of pathogens responsible for CRIs shows that gram-positive bacteria, particularly Coagulase-Negative Staphylococci (CoNS) (40.8%) and *Staphylococcus aureus* (29.2%), are the most common causative organisms. Gram-negative bacteria such as *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* were less frequent. This pattern highlights the importance of skin flora as primary pathogens in hemodialysis-related infections, which should be considered when selecting empirical antibiotic therapy [Table 2].

Table 2: Distribution of Patients with CRI with respect to Pathogen (Dominant Micro-Organism)

Pathogen	Number of Patients	% (N=120)	95% CI of %
Coagulase Negative Staphylococci (CoNS)	49	40.80%	32.0 – 49.6%
Staphylococcus aureus	35	29.20%	21.1 – 37.3%
Klebsiella pneumoniae	13	10.80%	5.1 – 16.5%
Pseudomonas aeruginosa	10	8.30%	3.4 – 13.2%
Enterobacter cloacae	7	5.80%	1.6 – 10.0%
Acinetobacter baumannii	6	5.00%	1.1 – 8.9%

The use of vancomycin alone increased under culture guidance (from 25.83% to 38.33%), while combination therapies like vancomycin with gentamicin saw a slight reduction. This shift suggests that culture results helped streamline therapy toward more targeted, often monotherapy, approaches in confirmed cases [Table 3].

Table 3: Frequency And Percentages of Empiric and Culture-Guided Antimicrobials Used

Antimicrobial Regimen	Empiric Therapy (n=120)	Culture Guided Therapy (n=120)
Vancomycin	31 (25.83)	46 (38.33)
Gentamicin	7 (5.83)	6 (5)
Amikacin	13 (10.83)	11 (9.17)
Vancomycin + Gentamicin	36 (30)	29 (24.17)
Vancomycin + Amikacin	14 (11.67)	12 (10)
Vancomycin + Ceftriaxone	11 (9.17)	9 (7.5)
Vancomycin + Gentamicin + Meropenem	5 (4.17)	5 (4.17)
Vancomycin + Meropenem	3 (2.5)	2 (1.67)

Table 4: Comparison of Multidrug-Resistant Organisms (MDRO) with respect to Recurrence

Type	Total	Recurrence	No Recurrence
MDRO, n (%)	88 (100)	37 (42.04)	51 (57.96)
Non-MDRO, n (%)	42 (100)	8 (19.05)	34 (80.95)
P-Value (Fisher's Exact Test)		**0.0108**	

88 (73.33%) cases were identified as MDRO. The comparison of MDRO with recurrence rates indicates that infections caused by MDROs were associated with a significantly higher recurrence rate (42.04%) compared to non-MDRO infections (19.05%). The p-value of 0.0108 confirms this association is statistically significant, underscoring the clinical challenge posed by MDROs in managing and preventing recurrent catheter-related infections in hemodialysis patients [Table 4].

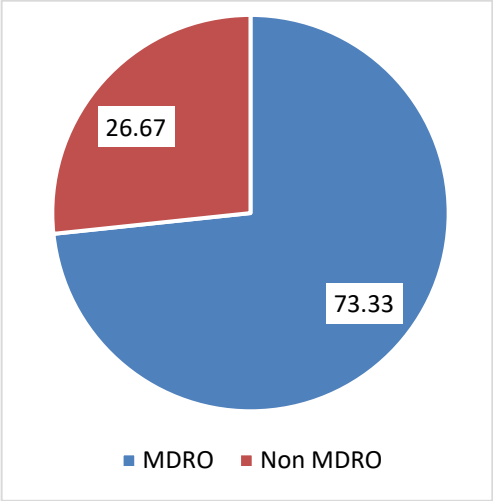

Figure 1: Distribution of CRI cases with respect to Multi-Drug Resistant Organisms

DISCUSSION

Catheter-related infections (CRIs) are a major cause of morbidity, hospitalization, and treatment disruption in patients on chronic hemodialysis. The scientific basis for this lies in the breach of the skin barrier by the central venous catheter, which provides a direct conduit for skin flora (like Coagulase-Negative Staphylococci - CoNS and *S. aureus*) to enter the bloodstream.[14] Biofilm formation on the catheter lumen is a critical pathogenic step, protecting bacteria from host immune defenses and antibiotics.

The high incidence of CRI (1.3 per 100 patient-months) underscores the persistent challenge of catheter care. The dominance of gram-positive organisms, particularly CoNS (40.8%) and *S. aureus* (29.2%), is a classic finding in many settings, reflecting the primary role of skin contamination during catheter handling.

The widespread use of vancomycin, both as empiric and culture-guided therapy, highlights its role as the cornerstone for treating suspected or confirmed gram-positive infections, especially given the high prevalence of methicillin-resistant staphylococci.[15] The shift towards more vancomycin monotherapy after culture results demonstrates an effort to de-escalate and streamline treatment, which is crucial for antimicrobial stewardship.

The most critical finding is the strong, statistically significant association (p=0.0108) between Multidrug-Resistant Organisms (MDROs) and a higher recurrence rate (42.04% vs. 19.05%). This has profound clinical implications, suggesting that infections with MDROs are not only harder to treat initially but also portend a worse long-term outcome, likely due to inadequate source control and limited effective antibiotic options penetrating the biofilm.

When placed in the context of global literature, the findings of this study reveal both consistent patterns and important geographical variations in the epidemiology of hemodialysis-related infections.

The present study's gram-positive dominance (CoNS and *S. aureus* comprising ~70% of pathogens) aligns closely with findings from AbuTaha et al. (2022) in Palestine (83.89% gram-positive) and Shahar et al. (2021) in Malaysia.[16, 17] This pattern is typical in settings with robust infection control practices that primarily prevent skin flora entry.

In stark contrast, the studies from Uganda (Nanyunja et al., 2022) and Ghana (Opoku-Asare et al., 2023) reported a predominance of gram-negative bacilli (60.3% and 52.9%, respectively).[18, 19] This striking difference likely reflects variations in hygiene and water sources, where contamination of the dialysis environment or the water used for dialysate may introduce gram-negative bacteria; catheter care practices, including differences in insertion techniques, dressing protocols, and antiseptic use, which can influence the predominance of specific microbial flora; and patient comorbidities, as regions with a higher burden of gram-negative infections may have populations with distinct underlying health conditions or increased susceptibility to gut translocation.

The high prevalence of MDROs in this study (88/120 cases) and their link to recurrence is a grave concern that finds echoes in other studies. AbuTaha et al. (2022) reported an even higher MDRO rate of 75.4%, also predominantly gram-positive.[17] However, Nanyunja et al. (2022) found 36.5% of isolates were MDR but were predominantly gram-negative.[18] This indicates that while MDR is a universal problem, the specific resistant pathogens (gram-positive vs. gram-negative) differ by region, necessitating local antimicrobial stewardship and empiric therapy guidelines.

The reliance on vancomycin in this study is consistent with its role as a first-line agent against gram-positive MDROs. The efficacy of vancomycin and gentamicin noted by AbuTaha et al. (2022) supports this combination for broad empiric coverage in high-MDR settings.[16] For gram-

negative dominant settings like those in Uganda, Ghana, and North India (Aslam et al., 2025), carbapenems (imipenem/meropenem) were highlighted as effective, reflecting local resistance patterns.[18-20]

The systematic review by Rabindranath et al. (2009) provides a critical preventive context. Their finding that Antimicrobial Lock Solutions (AMLs) significantly reduce CRBSI rates offers a proven strategy to address the high incidence and recurrence rates observed in all these studies, including the present one.[21] The failure of the present study and others to control recurrence, especially with MDROs, argues strongly for the wider implementation of AMLs as a standard of care.

The low mortality (1.1%) in Shahar et al. (2021) and zero deaths in El-Kady et al. (2021) contrast with the significant morbidity of recurrence found in the present study.[17, 22] This suggests that while CRIs may not always be immediately fatal, they lead to a burdensome cycle of recurrence, particularly with MDROs. The risk factors identified in other studies—such as anaemia and prior infection (Nanyunja et al.).[18], femoral catheterization (Shahar et al.; Aslam et al.).[17, 20], and dialysis duration (Opoku-Asare et al.).[19]—complement the present study's findings by highlighting the patient and access-related variables that can be targeted for prevention.

In summary, the present study contributes to the global understanding of CRIs by confirming the severe problem of MDROs and their direct link to treatment failure and recurrence. The comparative analysis reveals a clear geographical divergence in causative pathogens, underscoring that local epidemiology must guide empiric therapy. However, the threat of antimicrobial resistance and the challenge of recurrence are universal, calling for a dual strategy of aggressive, culture-guided targeted therapy and the widespread adoption of preventive measures like antimicrobial catheter locks to improve outcomes for this vulnerable patient population.

CONCLUSION

In conclusion, this study highlights a high incidence of catheter-related infections in the hemodialysis population, predominantly driven by Gram-positive organisms like Coagulase- Negative Staphylococci and *Staphylococcus aureus*, and demonstrates a critical shift towards vancomycin-based therapy following culture results. Most significantly, it establishes a strong and statistically significant association between multidrug-resistant organisms and a higher rate of infection recurrence, underscoring the persistent clinical challenge posed by antimicrobial resistance. When contextualized with global research, these findings reveal a key epidemiological divide in predominant pathogens by region but unite with other studies in identifying multidrug resistance as a universal threat that adversely impacts patient outcomes, thereby emphasizing the urgent need for enhanced local antimicrobial stewardship and the adoption of proven preventive strategies, such as antimicrobial catheter locks, to mitigate recurrence and improve long-term care.

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