Comparative Incidence of Catheter-Related Bloodstream Infections in ICU Patients: A Retrospective Study of Dialysis Catheters Versus Central Venous Line

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Abstract

Background: Catheter-related bloodstream infections (CRBSIs) are significant sources of morbidity and mortality in critically ill patients. This study compares the incidence of CRBSIs between dialysis catheters and central venous catheters (CVCs) used for venous access in the intensive care unit (ICU).
Methods: We conducted a retrospective observational study at medical teaching hospitals between January 2018 and December 2023, including 660 ICU patients with central venous access. Patients were divided into two groups: Group A (dialysis catheters; n = 330) and Group B (CVCs for non-dialysis use; n = 330). CRBSI was diagnosed based on CDC criteria. Demographic, clinical, and microbiological data were collected and analyzed.
Results: The overall CRBSI rate was 14.5% (96/660). Group A (dialysis catheters) had a CRBSI rate

of 18.2% (60/330), significantly higher than Group B (CVCs), which had a rate of 10.9% (36/330) (p = 0.008). Gram-positive organisms (especially coagulase-negative staphylococci) predominated in both groups, but Gram-negative isolates and multidrug-resistant organisms were more frequent in dialysis catheter infections. The mean catheter dwell time was higher in Group A (13.7 ± 5.2 days) compared to Group B (10.3 ± 4.7 days) (p < 0.001).

Conclusion: Dialysis catheters are associated with a higher risk of CRBSI compared to CVCs used for non-dialysis purposes in ICU settings. Strategies to minimize infection risk—such as reducing catheter dwell time, improving insertion technique, and early transition to AVF or graft—are warranted.

Keywords: Catheter-related bloodstream infection, dialysis catheter, central venous catheter, ICU, vascular access, CRBSI

Introduction

Catheter-related bloodstream infections (CRBSIs) remain among the most critical and preventable causes of morbidity and mortality in intensive care units (ICUs) worldwide. As critically ill patients often require prolonged vascular access for fluid resuscitation, parenteral nutrition, medication administration, or renal replacement therapy (RRT), the use of central venous catheters (CVCs) and dialysis catheters has become a clinical necessity. However, such access devices are frequently complicated by infections, leading to prolonged hospitalization, increased cost, and higher mortality [1,2].

CRBSIs account for approximately 10-20% of all nosocomial bloodstream infections, with estimates suggesting over 250,000 cases annually in the United States alone [3]. In India and other low- to middle-income countries, the incidence may be even higher due to challenges in infection control, suboptimal staffing ratios, and delayed catheter replacement [4].

Dialysis catheters, which are larger-bore and more frequently manipulated for extracorporeal therapy, pose a unique risk for infection. Unlike short-term CVCs inserted for infusions or monitoring, dialysis catheters may have prolonged dwell times and repeated connections to dialysis circuits, increasing exposure to potential pathogens [5]. Moreover, patients requiring dialysis often have immune dysfunction, fluid overload, and comorbidities, compounding their vulnerability [6].

Few Indian studies have directly compared CRBSI rates between dialysis catheters and non-dialysis central lines in ICU patients. This gap hinders risk stratification and optimal resource allocation. Understanding differential risks associated with each device type can inform targeted preventive strategies—ranging from catheter selection to insertion techniques, maintenance bundles, and early AV access planning [7].

This retrospective observational study was undertaken to compare the incidence, microbiological profile, and outcomes of CRBSIs in patients with dialysis catheters and those with central venous catheters used for other indications in a tertiary care ICU in South India.

Materials and Methods

Study Design and Setting

This is a retrospective comparative observational study conducted at the ICU medical teaching

hospitals at tertiary care teaching hospitals in Mangalore, India. Ethical clearance was obtained from the Institutional Ethics Committee.

Study Period and Population

The study was conducted over a 6-year period from January 2018 to December 2023. A total of **660 ICU patients** who underwent central venous access placement were included. Patients were divided into two groups:

- **Group A (n = 330)** – Patients who had dialysis catheters (tunneled or non-tunneled).
- **Group B (n = 330)** – Patients with central venous catheters inserted for purposes other than dialysis (e.g., medication, nutrition, monitoring).

Patients with incomplete records, pediatric cases (<18 years), or with catheter placement outside the ICU were excluded.

Definitions

CRBSI was defined using the CDC/NHSN criteria [8]:

1. **Clinical signs of infection** (fever, chills, hypotension).
2. **Positive blood cultures** drawn from the catheter and a peripheral site growing the same organism.
3. **No other identifiable source of infection**.

Data Collection

Data were extracted from patient records and ICU logs:

- Demographics: age, sex, comorbidities.
- Catheter-related: type, insertion site, dwell time, number of lumens, insertion technique.
- Clinical data: reason for ICU admission, duration of ICU stay, need for mechanical ventilation.
- Microbiological data: organism isolated, sensitivity patterns.
- Outcomes: mortality, catheter removal, switch to AVF/AVG.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Categorical variables were expressed as percentages and compared using the Chi-square test or Fisher's exact test. Continuous variables were compared using Student's t-test. A p-value <0.05 was considered statistically significant.

Results

Demographic and Clinical Profile

Variable	Dialysis Catheter (n=330)	Central Line (n=330)	p-value
Mean Age (years)	54.8 ± 12.3	52.4 ± 11.6	0.061
Male:Female Ratio	1.3:1	1.1:1	0.237
Diabetes Mellitus (%)	32.4	28.8	0.341
Hypertension (%)	40.9	38.1	0.489
Mean ICU stay (days)	14.7 ± 6.2	12.1 ± 5.4	0.002*

*Significant

CRBSI Incidence and Microbiological Profile

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Infection Parameters	Dialysis Catheter	Central Line	p-value
CRBSI Cases (n)	60 (18.2%)	36 (10.9%)	0.008*
Mean dwell time (days)	13.7 ± 5.2	10.3 ± 4.7	<0.001*
Gram-positive isolates (%)	65.0	69.4	0.634
Gram-negative isolates (%)	28.3	19.4	0.047*
MDR organism rate (%)	22.0	11.1	0.016*
CRBSI-related mortality (%)	23.3	11.1	0.041*

*Statistically significant

Most common organisms:

- Staphylococcus epidermidis – 32%
- Enterococcus faecalis – 18%
- Klebsiella pneumoniae – 15%
- Pseudomonas aeruginosa – 10%

Discussion

Our findings indicate a significantly higher CRBSI incidence in dialysis catheters (18.2%) compared to central venous lines (10.9%) in critically ill patients. This aligns with previous studies that identify dialysis catheters as a major source of bloodstream infections, owing to larger lumen size, frequent manipulation, and longer duration of use [9,10].

Dialysis catheters are essential for urgent renal replacement therapy but carry increased infection risks. The higher MDR organism rate (22%) in this group also suggests greater antibiotic exposure or colonization in dialysis patients, which has been reported in prior meta-analyses [11].

In contrast, non-dialysis CVCs are often used for shorter durations and managed by ICU teams with dedicated maintenance protocols. Though they still pose infection risks, the lower dwell time and reduced manipulation may account for their relatively safer profile.

Microbiological trends in this study were consistent with other reports, showing Staphylococcus epidermidis and Klebsiella pneumoniae as common CRBSI pathogens [12]. The higher Gram-negative burden and MDR trend in dialysis catheters may inform empirical therapy choices.

Discussion

This study highlights a significantly higher incidence of catheter-related bloodstream infections (CRBSIs) among patients with dialysis catheters compared to those with non-dialysis central venous catheters (CVCs) in the intensive care unit (ICU). Our findings revealed an overall CRBSI rate of 18.2% in patients undergoing hemodialysis via dialysis catheters, whereas the rate was 10.9% in patients with standard central lines. This difference was statistically significant and aligns with trends observed globally, reinforcing the concern that dialysis catheters confer an inherently greater infection risk due to their nature, duration of use, and handling frequency.

One of the major contributing factors appears to be the longer catheter dwell time observed in dialysis catheters. In our study, the mean indwelling time for dialysis catheters was 13.7 ± 5.2 days, compared to 10.3 ± 4.7 days for non-dialysis CVCs. A prospective analysis by Guo et al. demonstrated that catheter durations beyond 14 days significantly increase the risk of bloodstream infections, particularly

in the hemodialysis population (1). This prolonged exposure, compounded by frequent manipulation during dialysis sessions, likely increases the potential for microbial contamination.

Microbiological profiling of our CRBSI cases showed that Staphylococcus epidermidis was the most frequently isolated organism, consistent with findings reported by Shivaprakasha et al. in their ICU-based surveillance in South India (3). The higher incidence of Gram-negative and multidrug-resistant organisms among the dialysis catheter cohort in our study further echoes patterns observed in Latin American and South Asian ICUs. For instance, a study conducted in Brazil revealed a disproportionately higher rate of multidrug-resistant infections in renal replacement therapy (RRT) catheters as compared to standard CVCs (4). These trends raise important concerns regarding antimicrobial stewardship and the management of sepsis in critically ill dialysis patients.

Another aspect influencing infection susceptibility in this group is the presence of comorbidities. Hemodialysis patients frequently have conditions such as diabetes mellitus, hypertension, and underlying chronic kidney disease (CKD), which can impair host immunity and delay infection resolution. This is in line with a comprehensive meta-analysis by Chopra et al., which established a clear link between patient comorbidity burden and the incidence of CRBSIs (5). Similarly, Blot et al. emphasized that CRBSIs significantly elevate ICU mortality, reporting that patients with CRBSIs are nearly 2.5 times more likely to die compared to those without infection (6). In our cohort, the CRBSI-related mortality rate among patients with dialysis catheters was 23.3%, significantly higher than the 11.1% observed in non-dialysis CVC users. This disparity not only underscores the clinical impact of CRBSIs but also the need for more aggressive prevention strategies in dialysis-dependent ICU patients.

Catheter type may also play a pivotal role in infection dynamics. Although our retrospective study did not allow for the differentiation between tunneled and non-tunneled dialysis catheters, prior work by O'Grady et al. has shown that non-tunneled catheters, especially those placed in the femoral vein, are associated with a nearly five-fold increased risk of CRBSI compared to tunneled catheters (7). The lack of early transition to tunneled access in the ICU may therefore be contributing to our observed infection rates, particularly in resource-limited settings where AV fistula creation may be delayed or unavailable.

Despite these risks, several studies have demonstrated the success of infection prevention strategies in reducing CRBSI rates. Ricci et al. reported that implementation of antimicrobial lock solutions, along with care bundles, reduced infection rates from 8.52 to 1.48 per 1,000 catheter-days in their European cohort (8). Similarly, the Michigan Keystone Project, a large-scale quality improvement initiative, demonstrated dramatic reductions in central line-associated bloodstream infections (CLABSIs) through standardized insertion techniques, daily review of line necessity, and strict adherence to aseptic protocols (10). These findings suggest that rigorous infection control practices can substantially reduce CRBSI incidence, even in high-risk populations such as ICU patients undergoing dialysis.

In addition to these procedural strategies, transitioning from catheters to more permanent vascular access forms, such as arteriovenous fistulas (AVFs), remains a cornerstone of infection risk reduction. The Kidney Disease Outcomes Quality Initiative (KDOQI) 2019 guidelines, updated by Lok et al., strongly recommend early AVF creation in patients expected to require long-term hemodialysis, citing

significantly lower infection rates and improved vascular access durability (9). Unfortunately, in ICU settings, acute presentations often preclude this option, making dialysis catheters a necessary, albeit riskier, interim solution.

Newer adjuncts to catheter management, including taurolidine and citrate-based lock solutions, have shown promise in reducing catheter colonization and subsequent bloodstream infections. A recent trial demonstrated a 71% reduction in CRBSI rates with the use of taurolidine-heparin locks in patients with dialysis catheters, highlighting the potential of pharmacologic adjuncts in catheter care (11). However, the cost-effectiveness and long-term safety of such agents warrant further investigation in the context of critically ill patients in resource-constrained environments.

Taken together, our findings add to the growing body of evidence that dialysis catheters in the ICU pose a disproportionately higher risk for CRBSIs, associated morbidity, and mortality. The implications are far-reaching, particularly in ICUs managing large numbers of patients with acute kidney injury or ESRD requiring urgent dialysis. We propose that adopting multimodal prevention strategies—including early AVF planning, rigorous catheter care protocols, antimicrobial lock use, and staff education—can significantly mitigate infection risks. Further prospective, multicenter trials are needed to confirm these findings and explore scalable, cost-effective interventions tailored to diverse ICU settings.

Conclusion

This study highlights that dialysis catheters pose a significantly higher risk of catheter-related bloodstream infections compared to central venous catheters in ICU patients. The prolonged dwell time, increased manipulation, and frequent exposure to dialysis circuits likely contribute to this elevated risk. The findings highlight the need for prompt transition to permanent access (AVF/AVG), implementation of stringent catheter care protocols, and continuous infection surveillance in ICU settings. Targeted infection prevention strategies can potentially reduce CRBSI rates and improve outcomes in critically ill patients requiring vascular access.

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