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Catheter Related Bloodstream Infections in a Tertiary Care Intensive Care Unit: Incidence, Risk Factors and Antimicrobial Susceptibility

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Abstract

Background: Catheter related bloodstream infections remain a leading cause of morbidity in intensive care units worldwide. Indian hospitals report rates several times higher than high income countries. Local microbiological and susceptibility data are essential for empirical therapy and prevention.

Objectives: To determine the incidence of CRBSI and to characterise risk factors, causative organisms and antimicrobial susceptibility patterns in an adult ICU of a tertiary care hospital.

Methods: This observational cross sectional study enrolled 100 consecutive adults with central venous or haemodialysis catheters in situ for more than 48 hours in the ICU of Sharda Hospital, Greater Noida (April 2024 to November 2025). Paired blood cultures (catheter drawn and peripheral) were collected at 48 hours and again on clinical suspicion of infection. CRBSI was diagnosed by differential time to positivity of two hours or more. Organisms were identified by standard biochemical methods and VITEK 2; susceptibility was tested by Kirby Bauer disc diffusion per CLSI guidelines.

Results: Thirty of 100 patients developed CRBSI (30%; incidence density 9.16 per 1,000 catheter days; 3,275 total catheter days). Gram negative organisms accounted for 53.3% of 30 isolates, Gram positive organisms 33.3% and yeasts 13.3%. *Escherichia coli* (20.0%) and *Klebsiella pneumoniae* (13.3%) were the most frequent pathogens. Resistance to ceftriaxone (100%), ciprofloxacin (100%) and meropenem (75%) was high among Gram negative isolates. Vancomycin, linezolid and teicoplanin retained 100% susceptibility against Gram positive organisms.

Conclusion: CRBSI incidence in this setting was comparable to other Indian tertiary care ICUs. Gram negative predominance with high resistance to cephalosporins and carbapenems supports broad spectrum empirical cover and early de-escalation guided by local susceptibility data. Strengthened bundle compliance and catheter day reduction are priorities for prevention.

Keywords: catheter related bloodstream infection; central venous catheter; antimicrobial susceptibility; intensive care unit; incidence; Gram negative bacteria

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Introduction

Intravascular catheters are indispensable in critical care. They provide reliable access for fluid administration, haemodynamic monitoring, parenteral nutrition, haemodialysis and chemotherapy. This dependence on central venous devices has created a persistent conduit for bloodstream infection.[1,2] Catheter related bloodstream infection (CRBSI) develops when organisms colonise the catheter surface or lumen and gain entry into the circulation; the process is reinforced by biofilm formation, which protects bacteria and fungi from host defences and antibiotics.[3,4]

CRBSI is among the most common healthcare associated infections globally. In the United States, more than 250,000 central line associated bloodstream infections occur annually, with attributable costs approaching US $46,000 per episode.[5] High income countries have reduced rates below one per 1,000 catheter days through evidence based bundles and national surveillance programmes.[6,7] Indian data present a different picture. A seven year multicentre surveillance across Indian hospitals reported a pooled CLABSI rate of 8.83 per 1,000 central line days in adult ICUs, several fold higher than Western benchmarks.[8] Single centre Indian studies report incidence rates between 7 and 25 per 1,000 catheter days; prevalence among catheterised patients has been recorded as high as 39%.[9-11]

The microbiological profile differs across regions. Western centres report predominance of Gram positive cocci, particularly coagulase negative staphylococci and *Staphylococcus aureus*.[5] Indian and other developing country cohorts report rising Gram negative infections, including *Klebsiella pneumoniae*, *Acinetobacter baumannii* and *Pseudomonas aeruginosa*, often with extensive multidrug resistance.[9,12,13] Candida species contribute a growing proportion, especially in patients receiving broad spectrum antibiotics or total parenteral nutrition.[14] These shifts demand local susceptibility data to guide empirical therapy and stewardship.

Data from the Greater Noida region on CRBSI burden, risk factors and resistance patterns are sparse. The present study aimed to determine the incidence of CRBSI, isolate and classify causative organisms and characterise antimicrobial susceptibility in the ICU of a tertiary care teaching hospital.

Materials and Methods

Study design and setting: This hospital based observational cross sectional study was conducted in the intensive care unit at the School of Medical Sciences & Research, Sharda Hospital, Greater Noida, from April 2024 to November 2025. Ethical approval was obtained from the Institutional Ethics Committee (Ref. No. SU/SMS&R/76-A/2024/179, dated 24/04/2024). The study was registered with the Clinical Trials Registry of India (CTRI/2025/02/080587). Written informed consent was obtained from each patient or their legally authorised representative.

Study population: Adults aged 18 years or older admitted to the ICU with a central venous catheter (CVC) or haemodialysis (HD) catheter in situ for more than 48 hours were eligible. Patients admitted from other hospitals with catheters already in place and those who were immunocompromised or had terminal illness (advanced malignancy, advanced congestive heart failure, stroke with coma) were excluded.

Sample size: Based on a CRBSI incidence of 5.1% reported by the National Nosocomial Infections Surveillance System, with a margin of error of 3% and significance level of 5%, the minimum required sample size was 203 patients. The study was time bound and hence enrolled 100 consecutive eligible patients.

Catheter insertion and maintenance: All catheter insertions were performed under maximal sterile barrier precautions by anaesthesiologists or intensivists. Skin preparation used 2% alcoholic chlorhexidine. The right internal jugular vein was the preferred site; alternative sites (left internal jugular, subclavian, femoral) were selected when clinically indicated. Triple lumen 7 French CVC or 12 French HD catheters were inserted according to clinical need. Post insertion care followed institutional protocols aligned with CDC and IDSA recommendations: no topical antibiotic ointment at the insertion site, sterile gauze dressings changed every 48 hours, hub disinfection with 2% chlorhexidine before each access.

Sample collection: Paired blood samples were collected 48 hours after catheter insertion as baseline screening. When CRBSI was subsequently suspected (fever, chills, hypotension, altered sensorium, unexplained rise in inflammatory markers or sepsis without identifiable focus), a second set of paired samples was obtained. Ten millilitres of blood were drawn simultaneously from the distal catheter port and from a peripheral vein under strict aseptic technique and inoculated into aerobic blood culture bottles (BACT/Alert system).

Microbiological processing: Blood culture bottles were incubated in the automated BACT/Alert 3D system. Differential time to positivity (DTP) was calculated for each pair; a DTP of two hours or more (catheter sample flagging positive earlier) was considered diagnostic of CRBSI. Positive bottles were subcultured on 5% sheep blood agar and MacConkey agar. Organisms were identified by colony morphology, Gram staining, biochemical tests and VITEK 2. Antimicrobial susceptibility testing was performed by the Kirby Bauer disc diffusion method per Clinical and Laboratory Standards Institute (CLSI) guidelines.

Statistical analysis: Descriptive statistics were analysed with SPSS version 28.0. Numerical variables were presented as mean plus or minus standard deviation; distributional/category based variables as frequencies and percentages. Pearson chi square test was used to assess associations between CRBSI and categorical risk factors. A p value below 0.05 was considered statistically significant. CRBSI incidence density was calculated as the number of CRBSI episodes divided by total catheter days multiplied by 1,000.

Results

Demographics and baseline clinical profile: The cohort comprised 100 patients (68 males, 32 females; male to female ratio 2.1:1). Mean age was 41.28 years (SD 12.06; range 20 to 78). The largest age group was 30 to 39 years (37.0%), followed by 40 to 49 years (23.0%) and 20 to 29 years (17.0%). Renal disease and neurological disorders were the most common admission diagnoses (24.0% and 22.0%). Haemodynamic instability (24.0%) and shock requiring vasopressors (20.0%) were the most frequent reasons for ICU admission (Table 1).

Table 1: Demographic and Baseline Clinical Characteristics (n = 100)

Variable	n	%
Age, years (mean ± SD)	41.28 ± 12.06	
20–29	17	17.0
30–39	37	37.0
40–49	23	23.0
50–59	16	16.0
≥60	6	6.0
Sex		
Male	68	68.0
Female	32	32.0
Primary diagnosis		
Renal disease	24	24.0
Neurological	22	22.0
Other/unspecified	24	24.0
Postoperative	10	10.0
Sepsis/septic shock	10	10.0
Cardiovascular/other	10	10.0
Reason for ICU admission		
Haemodynamic instability	24	24.0
Shock requiring vasopressors	20	20.0
Respiratory failure	17	17.0
Ventilatory support	17	17.0
Severe sepsis monitoring	12	12.0
Other	10	10.0

Catheter indication and exposure: The most frequent indications for catheter insertion were total parenteral nutrition (22.0%), multiple infusions (19.0%), haemodialysis (19.0%), vasopressor administration (16.0%) and difficult intravenous access (15.0%). Total catheter days for the cohort were 3,275 (mean 32.75 days per patient). At the baseline screening on day 1, no patient had a positive culture. The second paired sample, collected at a mean of 7.78 days (range 7 to 8) after insertion, yielded 30 culture positive episodes (30.0%), corresponding to a CRBSI incidence density of 9.16 per 1,000 catheter days (Table 2).

Table 2: Catheter Indication, Exposure and Culture Positivity (n = 100)

Variable	n	%
Indication for catheter		
Total parenteral nutrition	22	22.0
Multiple infusions	19	19.0
Haemodialysis	19	19.0
Vasopressors	16	16.0
Difficult IV access	15	15.0
Other	9	9.0
Catheter exposure		
Total catheter days	3,275	-
Mean catheter days per patient	32.75	-
Culture positivity		
First paired sample (day 1)	0	0.0
Second paired sample (day 7–8)	30	30.0
CRBSI incidence density	9.16 per 1,000 catheter days	-

Clinical signs at suspicion: Fever was the most frequently recorded clinical sign at the time of suspected CRBSI (43.0%), followed by hypotension or shock (22.0%), line site tenderness (19.0%), rigors during infusion (17.0%) and local catheter site signs (17.0%). Tachycardia with altered mental status was present in 3.0%.

Microbial organism distribution: The 30 isolates from CRBSI positive cases comprised Gram negative bacilli (16/30, 53.3%), Gram positive cocci (10/30, 33.3%) and yeasts (4/30, 13.3%). *Escherichia coli* was the most frequent organism (6/30, 20.0%), followed by *Klebsiella pneumoniae* (4/30, 13.3%), *Staphylococcus aureus* MSSA (4/30, 13.3%), *Pseudomonas*

aeruginosa (3/30, 10.0%) and *S. aureus* MRSA (3/30, 10.0%). Candida species accounted for four isolates (13.3%): *C. albicans* (2), *C. glabrata* (1) and *C. tropicalis* (1). The full distribution is shown in Figure 1 and Table 3.

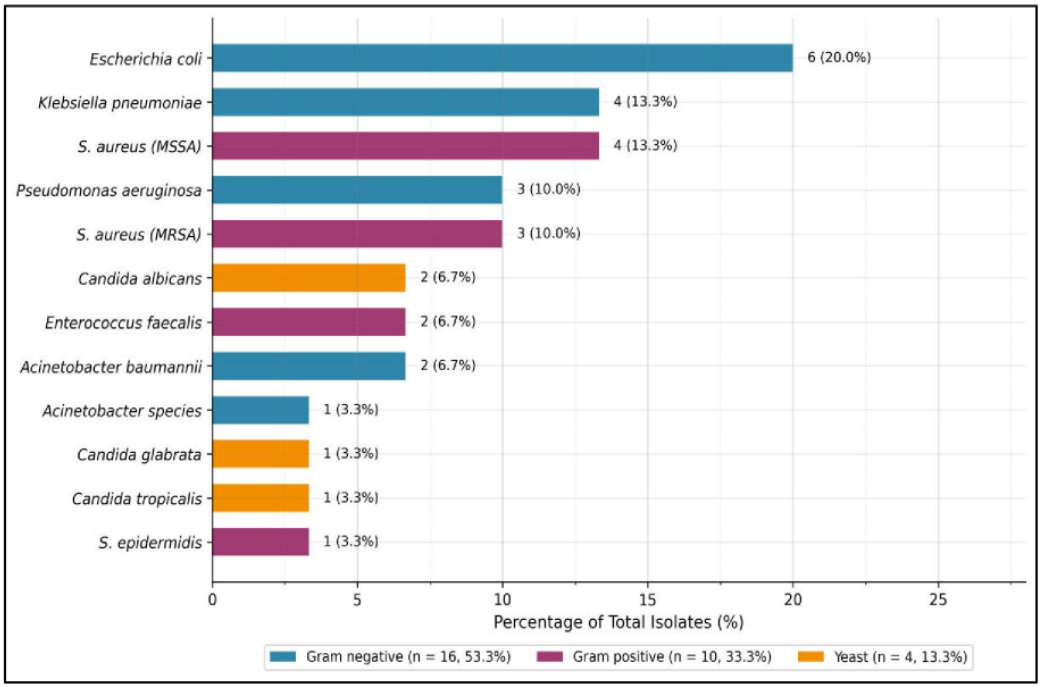

Figure 1: Distribution of causative organisms in catheter related bloodstream infections (n = 30 isolates). Bars are grouped by Gram class. Counts and percentages of total isolates are annotated.

Table 3: Microbial Organism Distribution among CRBSI Positive Cases (n = 30 isolates)

Organism	Count	% of isolates	Gram class
Escherichia coli	6	20.0	GN
Klebsiella pneumoniae	4	13.3	GN
S. aureus (MSSA)	4	13.3	GP
Pseudomonas aeruginosa	3	10.0	GN
S. aureus (MRSA)	3	10.0	GP
Candida albicans	2	6.7	Yeast
Enterococcus faecalis	2	6.7	GP
Acinetobacter baumannii	2	6.7	GN
Acinetobacter species	1	3.3	GN
Candida glabrata	1	3.3	Yeast
Candida tropicalis	1	3.3	Yeast

S. epidermidis	1	3.3	GP
Gram class summary			
Gram negative	16	53.3	
Gram positive	10	33.3	
Yeast	4	13.3	

GN, Gram negative; GP, Gram positive; MSSA, methicillin sensitive *Staphylococcus aureus*; MRSA, methicillin resistant *S. aureus*.

Antimicrobial susceptibility: The susceptibility profile of key antimicrobial agents is summarised in Table 4 and Figure 2. Third generation cephalosporins demonstrated poor activity; ceftriaxone showed 0% susceptibility (0/5 tested) and ceftazidime 25% (1/4). Carbapenems had limited efficacy among tested Gram negative isolates: meropenem susceptibility was 25% (1/4) and imipenem 0% (0/2). Amikacin showed 50% susceptibility (2/4). Ciprofloxacin and levofloxacin were uniformly resistant (0/3 and 0/2). Piperacillin tazobactam was susceptible in 33.3% (1/3) and cefoperazone sulbactam in 50% (1/2). Polymyxin B and colistin were categorised as intermediate in both isolates tested. Agents active against Gram positive organisms retained efficacy: vancomycin, linezolid and teicoplanin were each 100% susceptible (2/2). Daptomycin, tigecycline and ceftaroline were susceptible in all isolates tested (1/1 each). Small denominators limit precision and warrant cautious interpretation.

Table 4: Antimicrobial Susceptibility Profile of Key Agents

Antimicrobial	n tested	S (%)	I (%)	R (%)
Cephalosporins				
Ceftriaxone	5	0.0	0.0	100.0
Cefepime	4	25.0	0.0	75.0
Ceftazidime	4	25.0	0.0	75.0
Carbapenems				
Meropenem	4	25.0	0.0	75.0
Imipenem	2	0.0	0.0	100.0
Aminoglycosides				
Amikacin	4	50.0	0.0	50.0
Fluoroquinolones				
Ciprofloxacin	3	0.0	0.0	100.0
Levofloxacin	2	0.0	0.0	100.0

BL/BLI combinations				
Piperacillin/tazobactam	3	33.3	0.0	66.7
Cefoperazone/sulbactam	2	50.0	0.0	50.0
Polymyxins				
Polymyxin B	2	0.0	100.0	0.0
Colistin	2	0.0	100.0	0.0
Glycopeptides/Oxazolidinones				
Vancomycin	2	100.0	0.0	0.0
Linezolid	2	100.0	0.0	0.0
Teicoplanin	2	100.0	0.0	0.0

S, susceptible; I, intermediate; R, resistant; BL/BLI, beta lactam/beta lactamase inhibitor. Denominators are small for several agents and percentages should be interpreted with caution.

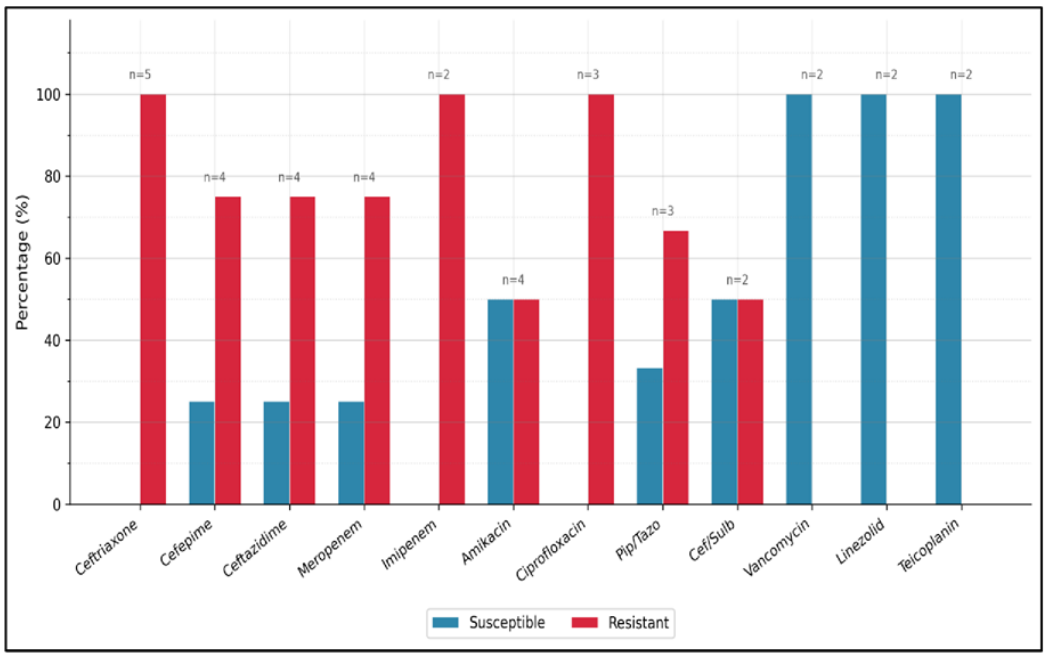

Figure 2: Antimicrobial susceptibility profile of key agents tested against CRBSI isolates. Grouped bars show percentage susceptible and resistant. The number of isolates tested for each agent (n) is annotated above bars. Agents are grouped by drug class.

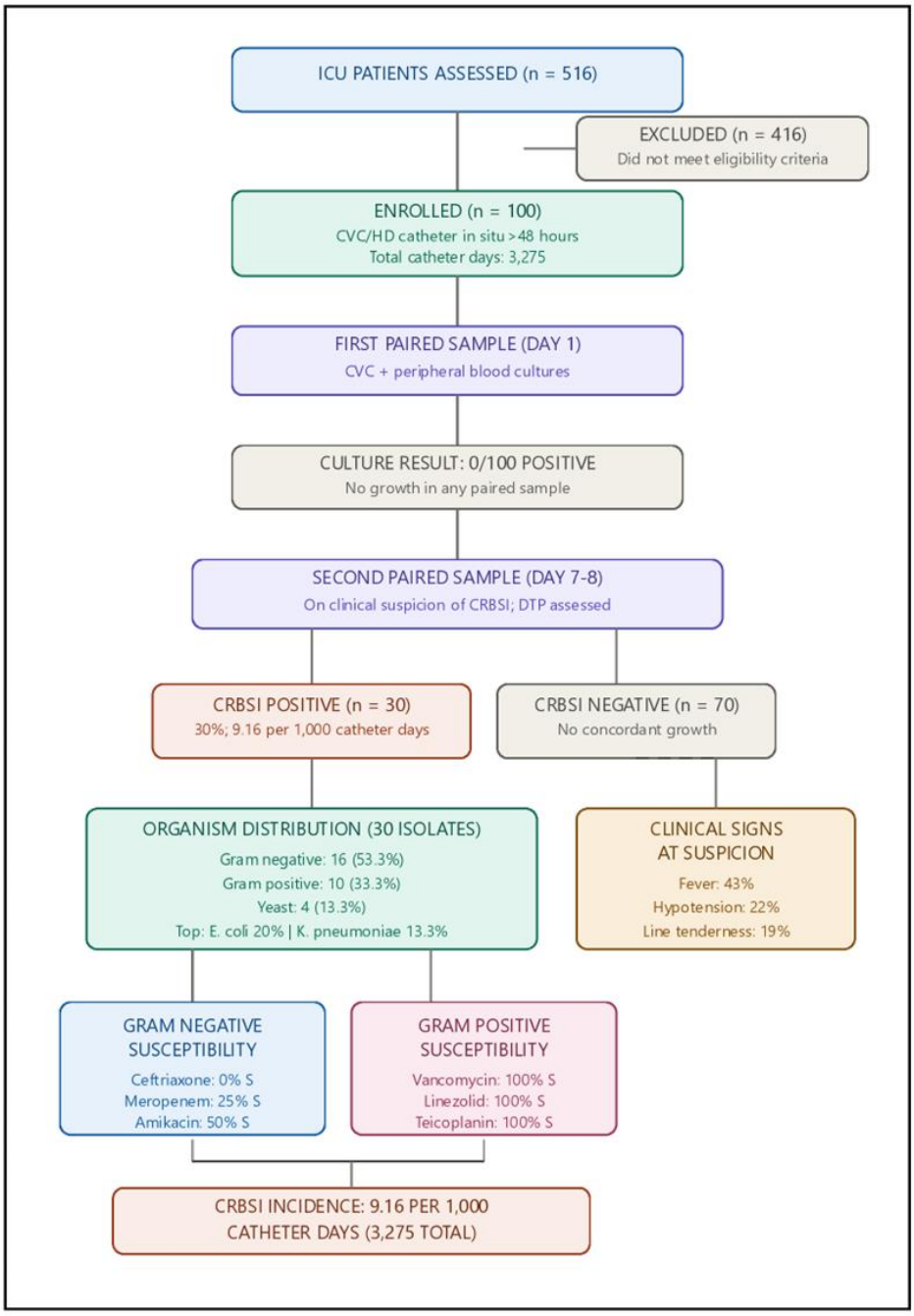

Figure 3 – Study Flowchart; *Legend: full pathway from ICU patient assessment (n = 516) through exclusion, enrollment (n = 100, 3,275 catheter days), both paired sampling episodes, the culture positivity split (30 CRBSI positive vs 70 negative), organism distribution by Gram class, susceptibility outcomes for both Gram negative and Gram positive isolates, clinical signs at suspicio, and the final incidence density (9.16 per 1,000 catheter days)*

Discussion

The present study documented a CRBSI prevalence of 30% and an incidence density of 9.16 per 1,000 catheter days among 100 ICU patients with central venous or haemodialysis catheters at a tertiary care hospital in northern India. The organism profile was Gram negative predominant with substantial representation of staphylococci and Candida species. Gram negative isolates exhibited extensive resistance to cephalosporins, carbapenems and fluoroquinolones; glycopeptides and oxazolidinones retained full activity against Gram positive pathogens.

The incidence density of 9.16 per 1,000 catheter days in this study aligned quite closely with recent Indian data. Maqbool and Sharma (2023), in a prospective study from a northern Indian medical ICU (186 patients, 3,994 catheter days), reported 9.3 per 1,000 catheter days.[9] Rai et al. (2023) recorded a CLABSI prevalence of 8.16% in 98 ICU patients using CDC/NHSN surveillance criteria.[10] The seven year Indian multicentre HAI surveillance network reported a pooled adult ICU rate of 8.83 per 1,000 central line days across 977,052 catheter days.[8] Our figure sits within this range and indicates that CRBSI burden in the Greater Noida region is consistent with the national average for Indian tertiary care ICUs. A trauma ICU study from Jaipur (Verma et al., 2023) reported a higher rate of 16.4 per 1,000 catheter days, attributable to the high acuity trauma population and emergency insertions under suboptimal conditions.[15] All Indian figures were substantially above US and European benchmarks of 0.5 to 1.0 per 1,000 catheter days, and reflect persisting gaps in bundle compliance, nurse to patient ratios and infrastructure.[5,6]

Culture positivity concentrated at the second sampling episode (mean 7 to 8 days after insertion); no organism grew at the 48 hour baseline. This pattern is consistent with the established pathogenesis of CRBSI: intraluminal contamination through hub manipulation becomes the dominant route after the first week, as biofilm matures and catheter handling frequency increases.[3,4] Pandit et al. (2021), in an Indian tertiary care hospital (2,800 screened, 82 confirmed CRBSI), reported that mean catheterisation time was significantly longer in CRBSI cases (12.19 days) than in uninfected patients (8.43 days; $p < 0.0001$), confirming the relationship between dwell time and infection.[11]

Gram negative bacilli accounted for 53.3% of isolates, consistent with the Gram negative shift reported across developing country settings. Maqbool and Sharma (2023) found 72% Gram negative organisms, dominated by *Acinetobacter* (22%) and *Klebsiella* (16%).[9] In the

Malaysian multicentre study by Rajandra et al. (2025), Gram negative organisms comprised 78.3% of isolates.[13] The present study differed in that *E. coli* (20.0%) rather than *Acinetobacter* was the most common organism, with *K. pneumoniae* second (13.3%). This likely relates to the high proportion of renal disease and haemodialysis catheters in our cohort, which may predispose to enteric organisms through gastrointestinal translocation. Gram positive organisms formed 33.3% of isolates; *S. aureus* (MSSA and MRSA combined, 23.3%) was the principal species. Li et al. (2025) reported Gram positive predominance (60.5%) in a Chinese ICU, with high resistance to penicillin and macrolides but preserved susceptibility to vancomycin and linezolid.[12] The discrepancy in Gram class distribution between our cohort and Chinese and Western data shows the need for region specific surveillance.

Candida species accounted for 13.3% of isolates, an important minority. Alwazzeh et al. (2023) documented an increase in Candida CLABSI to 24% over a decade of surveillance at a Saudi tertiary centre.[14] The relatively low fungal proportion in our study may reflect the exclusion of immunocompromised patients i.e., who form the highest risk group for candidaemia.

The antimicrobial susceptibility profile revealed a concerning burden of resistance among Gram negative isolates. Ceftriaxone susceptibility was 0% (5 tested), cefepime and ceftazidime 25% each, meropenem 25% and imipenem 0%. These findings are consistent with Pandit et al. (2021), who reported third generation cephalosporin resistance of 67% to 91% and carbapenem resistance of 20% to 42% among Gram negative CRBSI isolates.[11] Maqbool and Sharma (2023) found that polymyxin B was the only agent with 100% Gram negative susceptibility; tigecycline showed 85% sensitivity.[9] In our data, polymyxin B and colistin were categorised as intermediate in both isolates tested; the clinical interpretation of these results requires MIC based assessment, as disc diffusion is not recommended for colistin susceptibility testing. Agents targeting Gram positive organisms performed well: vancomycin, linezolid and teicoplanin were each 100% susceptible, consistent with Pandit et al. and Maqbool and Sharma.[9,11] Denominators for individual agents were small (2 to 5 isolates) and limit the precision of susceptibility estimates; these findings should be considered indicative rather than definitive.

The clinical implication is that empirical therapy in similar ICU settings should cover resistant Gram negative organisms. Piperacillin tazobactam or a carbapenem combined with vancomycin may serve as an initial empirical regimen, with prompt de-escalation once

susceptibility results are available. Local antibiograms should guide therapeutic choices. Stewardship programmes must be reinforced to slow the progression of resistance.

Strengths of this study include the use of differential time to positivity for CRBSI confirmation, standardised catheter insertion and maintenance protocols and prospective paired culture collection. Several limitations must be acknowledged during interpretation of our study results. The single centre cross sectional design and sample size of 100 patients limited generalisability and statistical power. Formal multivariate logistic regression was not performed because of the small number of CRBSI events. Immunocompromised patients were excluded and this restricts the applicability of findings to a large ICU subpopulation. Susceptibility testing denominators were small for many agents. The study did not capture catheter tip cultures for all patients or daily denominator data according to CDC/NHSN methodology. Future multicentre prospective studies with larger sample sizes, standardised daily surveillance and formal risk factor modelling are needed to refine these estimates.

Conclusion

CRBSI incidence in this tertiary care ICU was 9.16 per 1,000 catheter days, comparable to other Indian centres. Gram negative organisms predominated and displayed extensive resistance to cephalosporins, carbapenems and fluoroquinolones. Vancomycin and linezolid retained full activity against Gram positive isolates. Empirical therapy should provide broad Gram negative and Gram positive cover, with rapid de-escalation guided by culture results. Strengthened catheter care bundle compliance, daily assessment of line necessity and reduction of catheter dwell time are essential to lower infection rates. More expansive studies across diverse centres are required to validate risk factors and define optimal prevention strategies.

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