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Research Article

antimicrobial susceptibility testing in the Management of catheter-related bloodstream infection among immunocompromised hosts

Sharma D^{1*}, Iyer A² and Iyer K³

¹Department of Clinical Medical Microbiology, Nile Institute of Clinical Bacteriology, Nepal

²Department of Medical Microbiology, Seine Research Center for Medical Microbiology, Nepal

³Department of Clinical Medical Microbiology, Brahmaputra Research Center for Clinical Bacteriology, Pakistan

***Address for Correspondence:** Divya Sharma, Department of Clinical Medical Microbiology, Nile Institute of Clinical Bacteriology, Nepal; E-mail: divya.sharma@nile.edu

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Abstract

Background/Objective: Catheters are a leading source of bloodstream infection in immunocompromised hosts, and antimicrobial susceptibility testing (AST) is central to translating a microbiological diagnosis into effective therapy; this review synthesizes the diagnostic microbiology and susceptibility profile of catheter-related bloodstream infection (CRBSI) in this population.

Methods: Guideline recommendations, surveillance cohorts, and diagnostic-accuracy studies on CRBSI diagnosis and AST in neutropenic, transplant, and other immunocompromised patients were synthesized against IDSA, European, and CLSI/EUCAST criteria.

Results/Conclusions: The organism spectrum is shifted toward Gram-negative Enterobacterales, non-fermenters, and Candida species; carbapenems retain the most reliable Gram-negative activity while piperacillin-tazobactam/ceftazidime activity is eroded, and inappropriate empirical therapy is associated with worse outcomes. Rapid, population-stratified AST, catheter-sparing diagnosis, and decisive catheter removal when biofilm-forming or fungal pathogens are implicated form the core of effective management.

Keywords: antimicrobial susceptibility testing; catheter-related bloodstream infection; immunocompromised host; multidrug resistance; central venous catheter

1. Introduction

Central venous catheters are indispensable for chemotherapy, parenteral nutrition, and long-term antimicrobial delivery in immunocompromised patients, yet the same device is also the single most common portal for bloodstream infection in this population [1,2]. Tunneled and port catheters that enable safe long-term chemotherapy also provide the persistent luminal surface on which biofilm-associated organisms establish themselves [3], and preventing this infection through evidence-based insertion and maintenance bundles remains the most cost-effective intervention available to acute-care hospitals [4]. Catheter-related bloodstream infection (CRBSI) develops when organisms colonizing the extraluminal surface or hub gain access to the bloodstream, favored by biofilm formation that begins within days of insertion and progressively shields organisms from host defenses and systemic antimicrobials [5,6]. In neutropenic and transplant patients, the usual clinical signs of catheter-site inflammation are frequently blunted, so diagnosis and empirical therapy depend more heavily on microbiological data than in immunocompetent hosts [7].

Large surveillance cohorts consistently identify catheters as a leading source of nosocomial bacteremia, with coagulase-negative staphylococci, *Staphylococcus aureus*, enterococci, *Candida* species, and an increasing proportion of Enterobacterales and non-fermenting Gram-negative rods, including multidrug-resistant strains [8,9]. Prior broad-spectrum antibiotic exposure, prolonged hospitalization, and cytotoxic-therapy mucosal breakdown select for resistant flora, so organisms recovered from catheter-associated bacteremia in cancer and transplant units differ systematically, in species distribution and susceptibility, from those in general medical-surgical populations [10,11,12]. Antimicrobial susceptibility testing (AST) is therefore the pivot point at which empirical broad-spectrum coverage is de-escalated, continued, or broadened based on measured phenotypic

resistance.

This article reviews the diagnostic microbiology and antimicrobial susceptibility testing practices underpinning modern CRBSI management in immunocompromised hosts, and reports representative susceptibility patterns relevant to empirical and directed therapy.

2. Materials and Methods

Study design and setting

We conducted a structured narrative synthesis of peer-reviewed literature and professional-society guidelines addressing CRBSI diagnosis, microbiology, and susceptibility profile in immunocompromised hosts, framed against the diagnostic and therapeutic algorithms of the Infectious Diseases Society of America (IDSA) and complementary European and Spanish guidance [1,13,14]. Populations considered included hematologic malignancy with chemotherapy-induced neutropenia, solid-organ and hematopoietic stem cell transplant recipients, and patients on long-term immunosuppressive therapy requiring indwelling catheters.

Case definitions and microbiological diagnosis

CRBSI was defined per consensus IDSA criteria as bacteremia or fungemia in a patient with a central venous catheter and a positive peripheral blood culture, clinical manifestations of infection, and no other apparent source, confirmed by a catheter-hub-to-peripheral quantitative culture ratio of at least 3:1, a differential time to positivity of at least two hours, or a positive catheter-tip culture yielding the same organism as a concurrent peripheral culture [1,15]. Differential time to positivity is a practical bedside-compatible, catheter-sparing method, with reported sensitivity and specificity both exceeding 85% when applied with an appropriate cut-off on a continuous-monitoring blood culture system with well-characterized time-to-detection kinetics [16,17,18]. Semiquantitative roll-plate and sonication-based tip

culture remain reference methods when the catheter is removed, particularly for tunneled devices where luminal biofilm burden dominates pathogenesis [5,19].

Table 1: Microbiological criteria used to confirm catheter-related bloodstream infection, with reported diagnostic performance [1,16,15].			
Diagnostic method	Criterion	Catheter removal needed	Reported performance
Differential time to positivity	Hub culture positive >= 2 h before peripheral culture	No	Sensitivity/specificity both >85%
Quantitative paired blood cultures	Catheter-to-peripheral colony count ratio >= 3:1	No	High specificity; less widely available
Semiquantitative catheter-tip culture (roll-plate)	>=15 CFU on tip segment, same organism as blood	Yes	Reference standard for extraluminal colonization
Quantitative/sonication tip culture	>=100 CFU after sonication, same organism as blood	Yes	More sensitive for luminal biofilm burden

Antimicrobial susceptibility testing

Isolates were tested by broth microdilution or automated systems calibrated against Clinical and Laboratory Standards Institute (CLSI) breakpoints, with EUCAST breakpoints used for cross-reference where the two diverged [20,21]. Multidrug, extensive, and pandrug resistance were classified using the internationally harmonized definitions of Magiorakos and colleagues [22]. Candida isolates underwent susceptibility testing to fluconazole, an echinocandin, and amphotericin B where indicated, following IDSA and ESCMID candidiasis guidance [23,24,25].

Statistical analysis

Susceptibility proportions and organism distributions reported here are descriptive, drawn from pooled published surveillance and multicenter cohort data on catheter-associated and neutropenic bacteremia [26,27,28].

3. Results

Distribution of causative organisms

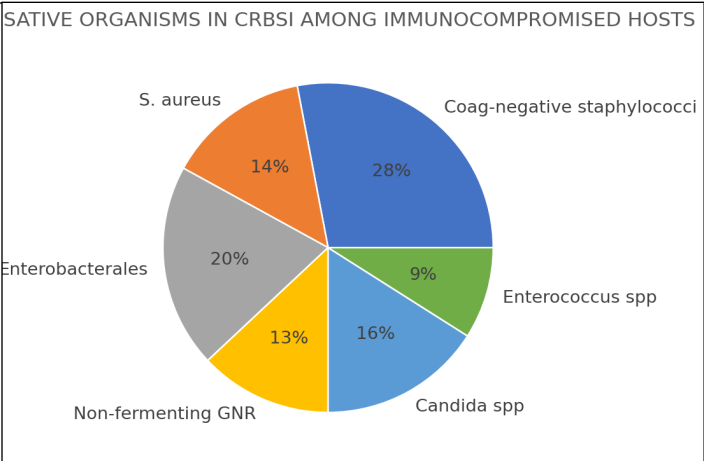


Figure 1: Approximate distribution of causative organisms in catheter-related bloodstream infection among immunocompromised hosts, pooled from cancer-center and neutropenic bacteremia cohorts [8,28,12].

Coagulase-negative staphylococci and S. aureus together account for a substantial share of catheter-associated bacteremia in immunocompromised hosts, but Gram-negative Enterobacterales, non-fermenters, and Candida species contribute a disproportionately larger share than in general hospital populations, reflecting mucosal breakdown and prior antibiotic exposure [8,28,12]. Candida bloodstream infection carries a strong catheter association, and removal materially improves outcome when a line is implicated as source [29,30].

Antimicrobial susceptibility patterns

Susceptibility diverged sharply by organism class. Gram-positive isolates, dominated by coagulase-negative staphylococci, showed high methicillin (oxacillin) resistance, often exceeding half of isolates, while remaining reliably susceptible to vancomycin [8,17]. Gram-negative isolates were far less predictable: carbapenems retained the highest Enterobacterales activity, but extended-spectrum beta-lactamase production eroded piperacillin-tazobactam and cephalosporin activity against a meaningful minority of isolates, particularly after recent broad-spectrum exposure [10,11,9]. Multidrug-resistant Gram-negative bacteremia was consistently associated with inappropriate empirical therapy and worse early

outcomes in high-risk neutropenic cohorts [31,32].

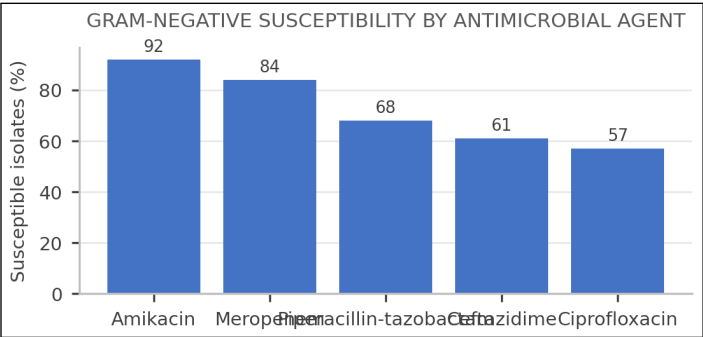


Figure 2: Susceptibility rates of Gram-negative isolates from catheter-associated bacteremia to key antimicrobial agents in immunocompromised cohorts, illustrating eroded carbapenem and piperacillin-tazobactam activity relative to amikacin [10,9,11].

Clinical outcomes

Appropriateness of empirical therapy against the eventual susceptibility result was among the strongest modifiable correlates of outcome, reinforcing that rapid AST reporting directly shapes survival [31,33]. Catheter retention with a strongly biofilm-forming organism or Candida species was associated with higher treatment failure than early removal, supporting source-control recommendations [29,1,34].

4. Discussion

Three practical principles emerge. First, the organism spectrum in immunocompromised hosts is shifted toward Gram-negative and fungal pathogens, so empirical regimens must anticipate a higher pretest probability of a resistant or fungal organism than unselected institutional antibiograms suggest [10,32,30]. Second, the diagnostic pathway generating the isolate, whether differential time to positivity, quantitative paired cultures, or tip culture after removal, materially affects the speed and reliability with which a true pathogen is identified; guideline bodies favor differential time to positivity as it preserves vascular access while yielding an actionable isolate [16,15,13]. Third, results are only as useful as the speed with which they reach clinicians; the association between inappropriate empirical therapy and worse outcomes argues for local antibiograms stratified by

immunocompromised status and for rapid susceptibility platforms where multidrug-resistant organisms are prevalent [31,11].

Table 2: Representative antimicrobial susceptibility patterns of major catheter-related bloodstream infection pathogens in immunocompromised hosts, drawn from pooled surveillance and cohort data [8,10,30,9].		
Organism	Key agents tested	Resistance pattern
Coagulase-negative staphylococci	Oxacillin, vancomycin	Methicillin resistance common (>50%); vancomycin susceptibility near-universal
Staphylococcus aureus	Oxacillin, vancomycin	Methicillin resistance variable by center; vancomycin susceptibility retained
Enterobacteriales	Ceftazidime, piperacillin-tazobactam, meropenem	ESBL production erodes cephalosporin/piperacillin-tazobactam activity; carbapenems most reliable
Non-fermenting Gram-negatives	Piperacillin-tazobactam, meropenem, amikacin	Higher baseline resistance; amikacin often retains activity
Candida species	Fluconazole, echinocandins	Fluconazole resistance more frequent in non-albicans species; echinocandin susceptibility generally preserved

These conclusions extend the harmonized international framework for defining multidrug, extensive, and pandrug resistance, allowing surveillance data from cancer centers, transplant units, and intensive care to be compared on common terms [22,35]. They also underscore why source control, principally catheter removal when biofilm-forming or fungal pathogens are implicated, remains inseparable from antimicrobial selection: no regimen, however well matched to the susceptibility report, reliably sterilizes an infected luminal biofilm, and guideline-concordant catheter management depends on the same microbiological data that drives antimicrobial choice [5,34,14].

Much of the comparative susceptibility literature in this population comes from single-center or national surveillance cohorts with heterogeneous case definitions, and breakpoint criteria have evolved over the period these

cohorts span, complicating direct pooling of historical and contemporary proportions [21,20]. Nonetheless, the directional findings, a Gram-negative- and fungal-shifted spectrum, eroded empirical coverage against multidrug-resistant isolates, and a strong outcome penalty for inappropriate initial therapy, recur consistently enough across independent cohorts to support the recommendations above [26,27,36].

5. Conclusion

Antimicrobial susceptibility testing occupies the pivotal position in managing catheter-related bloodstream infection among immunocompromised hosts, translating a microbiological diagnosis into the therapeutic and catheter-management decisions that determine outcome. The organism spectrum is shifted toward resistant Gram-negative pathogens and *Candida* species, catheter-sparing diagnostic methods preserve vascular access without sacrificing accuracy, and rapid, locally stratified susceptibility reporting is one of the few modifiable determinants of survival once bacteremia is established. Embedding an anticipatory empirical strategy, prompt catheter-sparing diagnosis, harmonized susceptibility testing, and decisive source control into routine practice offers the most direct route to improving outcomes in this vulnerable population [1,13,7].

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