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Central Line-Associated Bloodstream Infections in the Intensive Care Unit: A Narrative Review of the Multidisciplinary Synthesis of Radiologic Confirmation, Microbial Epidemiology, Nursing Stewardship, and Patient-Centered Outcomes

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Abstract

Background: Central line-associated bloodstream infections (CLABSIs) represent a significant cause of morbidity, mortality, and increased healthcare costs in intensive care unit (ICU) patients. While substantial literature exists on prevention bundles and microbiological surveillance, the critical interface between radiology and nursing in the comprehensive management of central venous catheters remains underexplored.

Aim: This narrative review synthesizes current evidence on the multidisciplinary management of CLABSIs in the ICU, with particular focus on the integration of radiologic confirmation of line placement, microbial epidemiology, nursing prevention strategies, and patient-centered care.

Methods: A comprehensive literature search was conducted using PubMed, CINAHL, Cochrane Library, and CDC databases for articles published between 2010 and 2024.

Results: Radiologic confirmation of central line placement using portable chest x-ray remains the standard for verifying tip position at the cavoatrial junction and ruling out pneumothorax, though emerging evidence supports ultrasound-based confirmation. The predominant pathogens include coagulase-negative staphylococci (12.5-31%), *Staphylococcus aureus* (6.3-16%), *Enterococci*, and *Candida* species, with increasing antimicrobial resistance. Nursing interventions, particularly standardized care bundles incorporating chlorhexidine bathing, dressing protocols, and daily line necessity assessments, reduce CLABSI rates by 21-68%. Patient-centered care addressing anxiety, discomfort, and education significantly improves satisfaction and clinical outcomes.

Conclusion: Effective CLABSI prevention and management requires seamless integration of radiologic verification, epidemiological surveillance, nursing vigilance, and compassionate patient care. Multidisciplinary collaboration, standardized protocols, and attention to the patient experience are essential for optimizing outcomes.

Keywords: CLABSI, central venous catheter, chest radiography, infection control bundle, patient-centered care

Introduction

Central line-associated bloodstream infections (CLABSIs) represent one of the most consequential and preventable complications in modern intensive care medicine. These infections occur when bacteria or fungi gain access to the bloodstream through central venous catheters (CVCs), devices that have become indispensable for the management of critically ill patients. Central lines facilitate hemodynamic monitoring, administration of vasoactive medications, delivery of total parenteral nutrition, and performance of renal replacement therapy (Gorski et al., 2021). However, this essential technology carries inherent risks that demand meticulous attention from the entire healthcare team.

The magnitude of the CLABSI problem is substantial. An estimated 250,000 bloodstream infections occur annually in the United States, with

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approximately 80,000 of these infections attributed to patients in intensive care units (Haddadin et al., 2017). Each CLABSI event imposes significant burdens: mortality rates ranging from 10% to 30%, additional hospital costs of approximately $46,000 per infection, and prolonged length of stay averaging 10-20 extra hospital days (Dube et al., 2020). When extrapolated nationally, the total annual cost of CLABSIs in the United States exceeds $1 billion (Haddadin et al., 2017). Critically, an estimated 65-70% of all CLABSIs are preventable through consistent application of evidence-based practices (Berenholtz et al., 2014).

The prevention and management of CLABSIs requires a truly multidisciplinary approach. Radiologists and intensivists must ensure correct line placement and promptly identify mechanical complications. Infection preventionists and microbiologists must track pathogen trends and antimicrobial resistance patterns. Bedside nurses serve as the "gatekeepers" of the line, performing daily assessments, maintaining sterile dressings, and advocating for timely line removal (Gorski et al., 2021). Finally, patients and families must be educated and supported through the experience of living with a central line (Altounji et al., 2020).

This narrative review examines the CLABSI problem through an integrated lens, synthesizing evidence from four domains: (1) the radiologic confirmation of line placement and identification of complications, (2) the epidemiology of causative microorganisms and resistance patterns, (3) nursing prevention strategies and care bundles, and (4) patient-centered considerations including anxiety, education, and the transition from hospital to home. By examining these interconnected elements, this review aims to provide a comprehensive framework for optimizing CLABSI prevention and management in the ICU setting.

The Role of Portable Chest Radiography

Following central line insertion, confirmation of correct positioning and exclusion of immediate mechanical complications are essential before the line can be used for its intended purposes. For decades, the portable anterior-posterior (AP) chest radiograph has served as the standard modality for this verification (Toy et al., 2022). In the intensive care unit, where patient transport poses risks and logistical challenges, bedside imaging offers a practical solution for confirming hardware placement without moving critically ill patients.

The ideal location for a central line placed via the internal jugular, subclavian, or peripherally inserted central catheter (PICC) approach is with the catheter tip positioned at the junction of the superior vena cava (SVC) and the right atrium (Gorski et al., 2021). This location ensures that infusates are delivered into high-flow central venous circulation while minimizing risks of cardiac arrhythmias, vessel erosion, or thrombus formation associated with more distal or proximal placements. On chest radiography, this corresponds to a position below the level of the carina and above the upper border of the cardiac silhouette, typically at the level of the sixth or seventh thoracic vertebra (Toy et al., 2022).

Radiographic assessment must also evaluate for malpositioning, which can occur in various directions. The catheter tip may be advanced too far into the right atrium or ventricle, increasing the risk of arrhythmias, myocardial perforation, or tamponade. Conversely, the tip may rest too proximally in the brachiocephalic vein or SVC, where higher osmolality medications or parenteral nutrition can cause phlebitis or thrombosis. In some cases, catheters inserted via the left subclavian or internal jugular approach may inadvertently traverse upward into the internal jugular vein rather than descending into the SVC (Toy et al., 2022).

Identifying Mechanical Complications

Beyond confirming tip position, chest radiography serves the critical function of identifying immediate mechanical complications of line insertion. Pneumothorax represents the most common and potentially life-threatening complication, occurring when the needle or catheter inadvertently punctures the visceral pleura during subclavian or internal jugular approaches. On supine chest radiographs, pneumothorax may appear as a deep sulcus sign—hyperlucency at the costophrenic angle—rather than the classic apical lucency seen in erect films (Toy et al., 2022). Hemothorax, though less common, may also occur and appears as opacification of the hemithorax on the affected side. Other mechanical complications identifiable on radiography include catheter kinking, fracture with embolization, and improper extravascular placement (Toy et al., 2022).

The importance of systematic radiographic evaluation cannot be overstated. Intensive care clinicians must develop proficiency in identifying not only central lines but also endotracheal tubes, chest tubes, feeding tubes, pulmonary artery catheters, pacemaker wires, and intra-aortic balloon pumps, all of which may be present in the complex ICU patient (Toy et al., 2022). Each device has specific radiographic criteria for optimal positioning, and malposition of any device carries distinct risks.

Emerging Role of Ultrasound Confirmation

While chest radiography remains the traditional standard, a growing body of evidence supports the use of point-of-care ultrasound for confirming central line placement and excluding pneumothorax (Smit et al., 2020; Thakur et al., 2020). Ultrasound offers several potential advantages, including real-time assessment, avoidance of ionizing radiation, and faster confirmation times—factors particularly valuable in critically ill patients requiring immediate line utilization.

The ultrasound confirmation technique typically involves injection of 5-10 mL of agitated saline through the distal port of the central line while visualizing the heart using echocardiography. Prompt appearance of microbubbles in the right atrium and ventricle (within 2 seconds of injection) confirms that the catheter tip resides within the central venous system, sufficiently distal for safe use (Thakur et al., 2020; Weekes et al., 2014). Concurrent assessment of lung sliding in both lung apices can exclude pneumothorax, as the absence of lung sliding on the side of insertion suggests pneumothorax.

Multiple studies have demonstrated that ultrasound confirmation is at least as accurate as chest radiography for detecting complications. Smit et al. (2020) conducted a multicenter diagnostic accuracy study comparing ultrasound to chest radiography for detecting central venous catheter placement complications, finding that ultrasound performed by trained operators had excellent sensitivity and specificity for detecting catheter malposition and pneumothorax. Zanobetti et al. (2013) compared ultrasonography and chest radiography in the emergency department setting, concluding that ultrasound verification was comparable to radiography and could be performed more rapidly. Similarly, Vezzani et al. (2010) found that ultrasound localization of central venous catheters and detection of postprocedural pneumothorax offered a valid alternative to chest radiography.

However, several limitations must be acknowledged. Ultrasound requires operator training and experience, may be challenging in patients with poor acoustic windows, and does not provide the comprehensive assessment of all thoracic structures that radiography affords (Smit et al., 2020). Furthermore, ultrasound cannot detect certain complications such as catheter kinking or fibrin sheath formation (Gekle et al., 2015). For these reasons, many institutions continue to require radiographic confirmation, particularly for catheters placed under emergent conditions or by operators with limited ultrasound experience.

The Epidemiological Dimension

Causative Pathogens

Understanding the microbial etiology of CLABSIs is essential for guiding empiric antibiotic therapy, implementing targeted prevention strategies, and tracking emerging resistance patterns. The epidemiology of CLABSI pathogens has been well-characterized through large surveillance systems, particularly the Centers for Disease Control and Prevention's National Healthcare Safety Network (NHSN) (O'grady et al., 2011).

The most commonly reported causative pathogens in CLABSIs are coagulase-negative staphylococci, accounting for approximately 12.5-31% of infections depending on the patient population and surveillance methodology (Niedner et al., 2011; Alwazzeh et al., 2023). These organisms, primarily *Staphylococcus epidermidis*, are ubiquitous components of human skin flora and typically gain access to the bloodstream through contamination of the catheter hub or migration along the external catheter surface (O'grady et al., 2011). While often considered contaminants when isolated from a single blood culture, their repeated isolation from a patient with clinical signs of infection confirms their pathogenic role in CLABSI.

Staphylococcus aureus represents the second most common gram-positive pathogen, responsible for approximately 6.3-16% of CLABSIs (Niedner et al., 2011; Alwazzeh et al., 2023). *S. aureus* infections are particularly concerning due to their potential for metastatic seeding, endocarditis, and high associated mortality. The proportion of methicillin-resistant *S. aureus* (MRSA) among ICU isolates has historically exceeded 50%, though recent years have seen declining MRSA CLABSI rates, likely attributable to successful prevention efforts (O'grady et al., 2011; Buetti et al., 2022).

Enterococci, including *Enterococcus faecalis* and *Enterococcus faecium*, account for a substantial proportion of CLABSIs, particularly in patients with prolonged hospitalizations, prior antibiotic exposure, or gastrointestinal disease (O'grady et al., 2011). Vancomycin resistance among enterococci poses significant treatment challenges and is increasingly prevalent in ICU settings (Niedner et al., 2011).

Gram-negative bacilli collectively account for approximately 19-21% of CLABSIs reported to surveillance systems (Niedner et al., 2011). Common isolates include *Klebsiella pneumoniae*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii* (Alwazzeh et al., 2023). These organisms may originate from the patient's endogenous flora, contaminated infusates, or environmental sources. The proportion of CLABSIs attributable to gram-negative organisms varies by patient population, with higher rates observed in burn units, neutropenic patients, and neonatal ICUs (O'grady et al., 2011).

Candida species, particularly *Candida albicans* and *Candida parapsilosis*, account for a significant minority of CLABSIs, especially in immunocompromised patients, recipients of total parenteral nutrition, and those with prolonged broad-spectrum antibiotic exposure (O'grady et al., 2011; Alwazzeh et al., 2023). Candida CLABSIs carry particularly high mortality rates and often necessitate catheter removal for cure.

Polymicrobial infections, involving two or more organisms, occur in a substantial proportion of CLABSIs. In one recent series, polymicrobial etiology was documented in 37.5% of cases, underscoring the complexity of these infections and the importance of comprehensive microbiologic evaluation (Alwazzeh et al., 2023). Table 2 provides a comprehensive summary of the microbial etiology of CLABSIs, including specific organisms, their approximate proportions, clinical implications, and resistance concerns. As detailed in the table, gram-positive cocci remain the predominant pathogens, though the increasing prevalence of antimicrobial resistance among both gram-positive and gram-negative organisms poses ongoing treatment challenges. The data presented in Table 2 synthesize findings from Niedner et al. (2011), O'grady et al. (2011), and Alwazzeh et al. (2023), highlighting the complex microbiological landscape that clinicians must navigate when managing suspected or confirmed CLABSIs.

Table 2: Microbial Etiology of CLABSIs and Clinical Implications

Pathogen Category	Specific Organisms	Approximate Proportion	Clinical Implications	Resistance Concerns
Gram-Positive Cocci	Coagulase-negative staphylococci	12.5-31%	Often skin contaminants; requires multiple positive cultures for confirmation	Methicillin resistance common
	Staphylococcus aureus	6.3-16%	High metastatic potential; associated with endocarditis; often requires line removal	MRSA historically >50% of isolates; declining with prevention efforts
	Enterococci (*E. faecalis, E. faecium*)	Variable	Associated with GI source; prolonged hospitalization; prior antibiotics	Vancomycin resistance increasingly prevalent
Gram-Negative Bacilli	*Klebsiella pneumoniae*	15.6% in some series	Increasing ESBL production; limited treatment options	3rd-gen cephalosporin resistance increasing
	Escherichia coli	Variable	Community and healthcare sources; variable resistance patterns	ESBL-producing strains increasing
	Pseudomonas aeruginosa	Included in 19-21% total GN	Associated with moist environments; difficult to treat	Carbapenem resistance increasing
	Acinetobacter baumannii	12.5% in some series	Highly resistant; associated with outbreaks in ICUs	Multidrug resistance common; carbapenem-resistant strains
Fungi	*Candida albicans*	6.3% in some series	Associated with TPN, broad-spectrum antibiotics, immunocompromise	Fluconazole resistance increasing
	Non-albicans Candida (*C. glabrata, C. parapsilosis*)	Variable	Increasing proportion of Candida CLABSIs	Variable azole susceptibility; some species intrinsically resistant
Polymicrobial	Two or more organisms	Up to 37.5%	Indicates complex infections; may involve both gram-positive and gram-negative organisms	Multiple resistance patterns; treatment requires coverage of all organisms

Note: GN = gram-negative; TPN = total parenteral nutrition; ESBL = extended-spectrum beta-lactamase; MRSA = methicillin-resistant *Staphylococcus aureus*

Antimicrobial Resistance

Antimicrobial resistance represents a growing challenge in the management of CLABSIs, particularly in ICU settings where selective pressure from broad-spectrum antibiotic use is intense (Niedner et al., 2011). Among gram-positive pathogens, methicillin resistance in *S. aureus* and vancomycin resistance in enterococci remain prevalent, though the incidence of MRSA CLABSIs has declined in recent years, possibly reflecting successful implementation of prevention bundles and MRSA-specific interventions (Buetti et al., 2022; O'grady et al., 2011).

Among gram-negative organisms, resistance patterns are increasingly concerning. Resistance to third-generation cephalosporins among *Klebsiella pneumoniae* and *E. coli* has increased significantly, driven largely by the spread of extended-spectrum beta-lactamase (ESBL)-producing strains (Niedner et al., 2011). Carbapenem resistance among *P. aeruginosa* and *Acinetobacter* species limits treatment options and is associated with worse outcomes. The emergence of carbapenem-resistant Enterobacteriaceae (CRE) in ICU settings represents a particularly urgent threat (Buetti et al., 2022).

Among *Candida* species, fluconazole resistance is increasingly noted, particularly in non-albicans species such as *C. glabrata* (O'grady et al., 2011). This trend has important implications for empiric antifungal therapy in high-risk patients.

Surveillance Metrics and Benchmarking

Surveillance for CLABSIs serves multiple purposes: tracking institutional rates over time, identifying outbreaks, guiding prevention efforts, and enabling comparisons with national benchmarks (O'grady et al., 2011). The NHSN provides risk-adjusted benchmarking data that allow hospitals to compare their CLABSI rates with those of similar institutions. These comparisons are adjusted for patient-related factors (severity of illness, case mix), catheter-related factors (type of catheter, insertion site), and institutional factors (bed size, academic affiliation) (O'grady et al., 2011).

CLABSI rates are typically expressed as the number of infections per 1,000 catheter-days, a metric that accounts for varying duration of catheter exposure (O'grady et al., 2011). This standardization enables meaningful comparisons across units and time periods. The Konnor's (2022) 2021 National and State Healthcare-Associated Infections Progress Report documented an overall 21% reduction in CLABSIs among hospitalized patients compared to baseline, with ICUs showing the largest reduction.

However, important gaps in surveillance exist. Outpatient CLABSI data are not consistently tracked at the national level, posing challenges for comprehensive prevention strategies (Nailon & Rupp, 2019). As more patients are discharged with central lines for home infusion therapy, this surveillance gap becomes increasingly problematic. Initiatives such as Whalen & Mack (2020) are working to improve outpatient CLABSI tracking and prevention.

The Central Role of Bedside Nursing

Bedside nurses serve as the primary guardians of central line integrity and the first line of defense against infection. In the complex environment of the intensive care unit, where multiple providers may access the line, and patients present numerous competing priorities, the nurse's vigilance is essential for maintaining aseptic technique, recognizing early signs of complications, and advocating for timely line removal (Gorski et al., 2021).

The scope of nursing responsibilities for central line management is broad and includes: assisting with insertion under sterile conditions, performing daily site assessments, executing dressing changes according to protocol, ensuring proper line and cap changes, monitoring for signs of infection, obtaining blood cultures correctly when infection is suspected, and participating in daily discussions of line necessity (Gorski et al., 2021; O'Grady et al., 2011).

The concept of care bundles—collections of evidence-based practices that, when implemented together, produce better outcomes than individual elements alone—has been central to CLABSI reduction efforts (Institute for Healthcare Improvement [IHI], 2017). The Institute for Healthcare Improvement's central line bundle, adapted and refined by numerous institutions, typically includes the following elements:

- Hand hygiene before line insertion and manipulation represents the most fundamental and effective infection prevention measure (Pittet et al., 2009). Despite its simplicity, consistent hand hygiene remains challenging to achieve, requiring ongoing education, monitoring, and feedback (Saint et al., 2023).
- Maximal sterile barrier precautions during insertion require the operator to wear a sterile gown, gloves, hat, and mask, and to cover the patient from head to toe with a large sterile drape, exposing only the puncture site (O'Grady et al., 2011). This approach dramatically reduces contamination during the insertion procedure.
- Chlorhexidine skin antisepsis using 2% chlorhexidine in 70% alcohol has demonstrated superiority to povidone-iodine for reducing skin flora at the insertion site and subsequent infection risk (O'Grady et al., 2011; Marschall et al., 2014).
- Optimal catheter site selection, with avoidance of the femoral vein for adult patients when possible, reduces infection risk associated with higher-density skin flora in the groin area (O'Grady et al., 2011).
- Daily review of line necessity with prompt removal of unnecessary lines is perhaps the most effective prevention measure, as infection risk increases with each day of catheterization (Marschall et al., 2014).

Beyond insertion bundles, maintenance bundles address ongoing line care. These include: chlorhexidine-impregnated dressings or biopatches at the insertion site, chlorhexidine bathing of ICU patients, standardized dressing change protocols, routine line and cap changes, and hub disinfection before each access (Buetti et al., 2022; Gorski et al., 2021). Table 1 summarizes the key evidence for CLABSI prevention interventions across insertion practices, maintenance practices, care bundles, patient/family education, and surveillance. As illustrated in the table, the evidence base supporting these interventions is robust, with comprehensive care bundles demonstrating 21-68% reductions in CLABSI rates (Linder et al., 2023; Sun et al., 2020). The table also highlights the importance of standardized protocols, multidisciplinary collaboration, and structured education in achieving sustained reductions in CLABSI incidence.

Table 1: Summary of Key Evidence for CLABSI Prevention Interventions

Intervention Category	Specific Intervention	Evidence Summary	Key Citations
Insertion Practices	Maximal sterile barrier precautions	Reduces contamination during insertion; essential bundle element	O'Grady et al., 2011; Marschall et al., 2014
	Chlorhexidine skin antisepsis	Superior to povidone-iodine for reducing skin flora	O'Grady et al., 2011; Marschall et al., 2014
	Ultrasound guidance for insertion	Reduces mechanical complications; emerging role for placement confirmation	Smit et al., 2020; Zanobetti et al., 2013; Vezzani et al., 2010
Maintenance Practices	Chlorhexidine-impregnated dressings	Variable evidence; benefits may depend on underlying protocol adherence	Yu et al., 2019; Webster et al., 2017
	Standardized dressing change protocols	Essential for maintaining site integrity; reduces exposure during changes	Burke et al., 2021; Gorski et al., 2021
	Chlorhexidine bathing of ICU patients	Reduces overall skin flora and CLABSI rates	Buetti et al., 2022
	Daily review of line necessity	Most effective prevention; removes infection risk entirely	Marschall et al., 2014
Care Bundles	Comprehensive insertion/maintenance bundles	21-68% reduction in CLABSI rates across multiple studies	Linder et al., 2023; Sun et al., 2020; Berenholtz et al., 2014
	CLABSI champion programs	Improves protocol adherence and provides peer support	Miller et al., 2011
	Multidisciplinary rounds	Enables real-time risk assessment and mitigation planning	Orozco-Santana et al., 2023
Patient/Family Education	Structured discharge education bundles	Zero community-acquired CLABSIs were reported post-implementation	Altounji et al., 2020
	Family advisory council involvement	Improves the relevance and acceptability of education materials	Altounji et al., 2020
Surveillance	NHSN participation	Enables benchmarking and trend identification	O'grady et al., 2011; Konnor, 2022
	Post-CLABSI "deep dive" reviews	Identifies contributing factors and informs process improvements	Miller et al., 2011

Evidence for Bundle Effectiveness

Multiple studies have demonstrated the effectiveness of comprehensive care bundles in reducing CLABSI rates. Linder et al. (2023) reported a 68% decline in CLABSI following implementation of comprehensive protocols. In a Chinese tertiary hospital study, Sun et al. (2020) found that implementation of care bundles including nurse education, hand hygiene protocols, maximal sterile barrier precautions, and systematic bedside evaluation significantly reduced CLABSI rates compared to conventional care.

Burke et al. (2021), in a scoping review, synthesized evidence on antimicrobial dressing strategies, finding that standardized dressing change protocols are essential for reducing CLABSI rates. While some studies have found no significant difference between chlorhexidine-impregnated and standard dressings when underlying care is excellent (Yu et al., 2019), the consistent message is that protocol adherence—regardless of specific product—matters more than individual product selection (Reynolds et al., 2021; Webster et al., 2017).

Pook et al. (2022) demonstrated that chlorhexidine locking solutions are more effective than standard methods for reducing bacterial growth in the catheter lumen. Mitchell et al. (2020) showed the benefits of sutured central lines with chlorhexidine discs and integrated securement devices. These findings underscore the importance of a multilayered approach addressing both the external insertion site and the internal lumen.

Daily Assessment and Surveillance

Daily assessment of the central line by bedside nursing staff is a cornerstone of prevention. The hourly line assessment recommended by many protocols includes inspection of the insertion site for erythema, tenderness, purulence, or drainage;

verification of dressing integrity and cleanliness; confirmation that all caps are securely attached; and assessment of the continued necessity of the line (Gorski et al., 2021).

In pediatric cardiac ICUs, specialized risk assessment tools such as the FLITES tool have been developed to identify patients at the highest CLABSI risk (Miller et al., 2011). This tool evaluates the Frequency of dressing changes and line entries; line days since insertion; immunocompromised status; tissue plasminogen activator (tPA) use; external visible length changes; and Skin integrity. Patients with multiple risk factors receive enhanced surveillance and targeted interventions.

Multidisciplinary leadership rounds, conducted weekly in many ICUs, bring together physicians, nurse practitioners, bedside nurses, infection preventionists, and process improvement specialists to review high-risk patients and develop mitigation plans focused on timely line removal (Orozco-Santana et al., 2023).

Obtaining Blood Cultures Correctly

When CLABSI is suspected—typically based on fever, chills, hypotension, or other signs of systemic infection—correct blood culture technique is essential for accurate diagnosis. The nurse's role in obtaining both peripheral venipuncture samples and samples through the central line, using strict aseptic technique, labeling specimens accurately, and ensuring prompt transport to the microbiology laboratory, directly impacts diagnostic accuracy (Gorski et al., 2021). Quantitative culture techniques, comparing colony counts from line-drawn and peripherally-drawn specimens, can help distinguish catheter-related infection from bacteremia originating elsewhere (O'Grady et al., 2011). Alternatively, differential time to positivity—comparing the time at which line-drawn and peripherally-drawn cultures become positive—provides diagnostic information, with line-drawn cultures turning positive at least 2 hours earlier suggesting catheter-related infection (O'Grady et al., 2011).

The Patient Care Dimension

While clinicians appropriately focus on infection prevention as the primary outcome, patients experience central lines through a different lens. For the critically ill patient, a central line represents one more piece of intimidating technology in an overwhelming environment. For the patient requiring prolonged intravenous therapy at home, the line becomes a constant presence affecting daily activities, body image, and psychological well-being (Sun et al., 2020). The presence of a central line near the heart can provoke anxiety in patients who are aware of its location and purpose (Effect of a Musical Intervention, 2022). Questions about movement restrictions, discomfort during line manipulation, fear of line dislodgement, and concerns about infection all contribute to the psychological burden. When patients are physically sick and treated in a hospital, they are more prone to develop anxiety and depression due to direct or indirect stress from their illness (Sun et al., 2020).

A randomized pilot study examining musical intervention during central line implantation found high baseline anxiety levels among ICU patients undergoing the procedure, though the musical intervention did not significantly reduce anxiety scores in this small study (Effect of a Musical Intervention, 2022). This finding underscores both the need for anxiolytic interventions and the challenge of modifying the inherently stressful experience of ICU care.

Effective communication about central lines begins before insertion and continues throughout the duration of line placement. Patients and families deserve clear explanations of why the line is necessary, what the insertion procedure involves, how the line will be managed, what signs of complications to watch for, and what to expect during line removal (Gorski et al., 2021). For patients discharged with central lines, comprehensive education becomes even more critical. The transition from hospital to home shifts responsibility for line care from trained healthcare professionals to patients and family caregivers who may lack formal medical training (Altounji et al., 2020). This transition creates significant challenges: limited access to immediate healthcare guidance, inadequate home resources, and potential underestimation of infection risks (Raimbault et al., 2023; Khanlou et al., 2022).

A quality improvement project by Altounji et al. (2020) addressed this gap by creating an Outpatient Pediatric Central Line Education Bundle for pediatric oncology patients discharged with central lines for continuous home infusion. The bundle standardized education and supplies for patients and families, incorporating input from patient and family advisory councils. Following implementation, zero community-acquired CLABSIs were reported, demonstrating the effectiveness of structured discharge preparation. Effective patient education must consider developmental needs, health literacy, language barriers, and cultural factors (Soto et al., 2022). For pediatric patients, education should be tailored to the child's developmental stage, with age-appropriate explanations and involvement of both patient and caregivers. For patients with emotional or developmental disabilities, maintaining proper care may require additional support and modified teaching approaches (Khanlou et al., 2022).

The Psychological Impact

The psychological impact of central lines extends beyond insertion-related anxiety. For patients requiring prolonged therapy, the line becomes a constant reminder of illness, a barrier to normal activities, and a source of altered body image (Sun et al., 2020). Showering, sleeping, and dressing may all require modification. Social activities may be curtailed due to concerns about line damage or infection. In the study by Sun et al. (2020), patients receiving care bundles—which included structured education and systematic evaluation—demonstrated significantly lower anxiety and depression scores on the Self-Rating Anxiety Scale (Zung, 1971) and Self-Rating Depression Scale (Zung, 1965) compared to patients receiving conventional care. This finding suggests that comprehensive, patient-centered approaches to line management can improve both infection outcomes and psychological well-being.

Satisfaction with hospitalization was also significantly higher among patients receiving care bundles, with satisfaction rates exceeding 90% in the intervention group compared to approximately 70% in the control group (Sun et al., 2020; Sun et al., 2017). These improvements likely reflect the combined effects of better clinical outcomes, enhanced communication, and attention to the patient's emotional needs. For many patients, line removal represents a significant milestone—a tangible step toward recovery and a return to normalcy (Gorski et al., 2021). Yet the removal procedure itself can provoke anxiety, particularly if patients are uncertain about what to expect. Clear explanation of the removal process, assurance that discomfort will be minimal, and education about post-removal site care can ease this transition.

Following removal, patients should be educated about signs of complications—bleeding, infection at the former insertion site, or delayed symptoms suggesting line-related sequelae (Gorski et al., 2021). For patients who have had lines in place for extended periods, the experience of being "line-free" may prompt both relief and, paradoxically, anxiety about losing a connection to medical care. In pediatric settings, particularly, family-centered care is essential for optimal outcomes (Altounji et al., 2020). Parents and caregivers must be active partners in line care, equipped with the knowledge and resources to maintain aseptic technique at home, recognize early signs of complications, and access healthcare support when needed.

The burden on caregivers should not be underestimated. Managing a child's central line at home requires vigilance, technical skill, and emotional resilience. Caregivers may experience anxiety about their ability to perform required tasks correctly, fear of causing harm, and stress related to the constant responsibility (Khanlou et al., 2022; Soto et al., 2022). Support systems—including clear communication channels with healthcare providers, access to home care nursing, and connection with other families facing similar challenges—can help alleviate this burden. Family and Youth Advisory councils, as utilized in the Altounji et al. (2020) project, provide valuable input for developing patient-centered materials and processes. Involving patients and families in quality improvement efforts ensures that interventions address real-world needs and challenges.

The Multidisciplinary Approach to CLABSI Prevention

Effective CLABSI prevention requires more than checklists and protocols; it demands a culture of safety in which every team member feels empowered to speak up about concerns, question practices that deviate from standards, and contribute to continuous improvement (Pronovost, 2008). This culture must span traditional disciplinary boundaries, recognizing that radiologists, intensivists, nurses, infection preventionists, and patients all have essential roles. In institutions with strong safety cultures, CLABSI rates are lower, protocol adherence is higher, and adverse events are more readily identified and addressed (Berenholtz et al., 2014; Pronovost, 2008). Leadership commitment, transparent reporting of outcomes, and celebration of successes all contribute to building and sustaining this culture.

The interfaces between disciplines represent potential points of vulnerability or opportunity. Communication between radiology and nursing, for example, ensures that line placement confirmation is promptly conveyed to the bedside team, that questions about positioning are addressed, and that concerns about line integrity are escalated appropriately (Toy et al., 2022). Structured communication tools—such as the Situation-Background-Assessment-Recommendation (SBAR) format—facilitate clear information transfer during handoffs, whether between shifts, between units, or between inpatient and outpatient settings (IHI, 2017). Daily multidisciplinary rounds provide forums for real-time discussion of high-risk patients and collaborative problem-solving (Orozco-Santana et al., 2023).

Standardization of processes—from insertion protocols to maintenance bundles to discharge education—reduces variation and improves reliability (Berenholtz et al., 2014). When every team member follows the same steps, using the same equipment, with the same documentation requirements, the likelihood of errors decreases. The "CLABSI Caddy" described by Miller et al. (2011) exemplifies this principle: a basket containing all supplies needed for dressing change in a single location, eliminating the need for staff to leave the bedside with the line exposed while gathering forgotten supplies. This simple intervention addresses a common failure point identified through event review.

Every CLABSI represents a failure of prevention and an opportunity for learning. Thorough event review—including "deep dive" investigations examining details around the event, parent interviews when applicable, and multidisciplinary discussion—identifies contributing factors and informs process improvements (Miller et al., 2011). The Plan-Do-Study-Act (PDSA) methodology provides a structured approach to testing and implementing changes (IHI, 2017). Small-scale tests of change allow rapid iteration and refinement before broad implementation. When effective interventions are identified, dissemination across units and institutions spreads best practices and accelerates improvement.

Future Directions

Several promising technological innovations and research directions warrant attention to further reduce CLABSI rates. Antimicrobial-impregnated catheters and advanced securement devices may reduce infection risk, though evidence regarding their effectiveness remains variable (Mitchell et al., 2020; O'Grady et al., 2011). Ultrasound guidance for line placement confirmation offers potential advantages over traditional radiography, including reduced time to line utilization and elimination of radiation exposure (Smit et al., 2020; Thakur et al., 2020). Electronic surveillance systems integrated with electronic health records could enhance prevention efforts by automatically identifying high-risk patients and tracking bundle compliance (Saint et al., 2023). Critical research priorities include optimizing dressing change protocols, evaluating long-term outcomes of prevention strategies, and conducting implementation science research to identify factors facilitating adoption of evidence-based practices (Buetti et al., 2022; Burke et al., 2021; Pronovost, 2008). Ongoing education, competency assessment, and simulation-based training for all team members remain essential for maintaining high standards of care (Aloush & Alsaraireh, 2018).

Conclusion

Central line-associated bloodstream infections (CLABSIs) are preventable complications with serious impacts on patients and healthcare systems. Effective prevention requires collaboration among various disciplines. Radiology confirms proper line placement and identifies issues, while epidemiology and microbiology inform pathogen understanding and guide therapy. Nursing plays a crucial role in monitoring, aseptic technique, and advocacy for timely line removal. Patient-centered care enhances the experience and outcomes by engaging patients and families in the process. This multidisciplinary approach is essential in intensive care units to ensure patient safety and the effective use of central lines.

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