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Review Article

Prevention and risk factors associated with incidence of central line associated bloodstream infection: a narrative review

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ABSTRACT

Central line-associated bloodstream infections (CLABSI) are a critical concern in healthcare settings, associated with high mortality rates and substantial financial burdens. This article highlights the various risk factors contributing to CLABSI, emphasizing both intrinsic and extrinsic factors, such as patient age, gender, underlying medical conditions, and catheterization duration. The prevention of CLABSI is addressed through a comprehensive bundle of evidence-based interventions, including hand hygiene, proper catheter insertion, skin preparation, catheter kits, selection of catheters, and maintenance bundles. Antimicrobial lock and flush solutions are crucial in eradicating microbes within catheter lumens. Furthermore, chlorhexidine bathing is recommended to reduce skin contaminants. Implementing these strategies collectively can significantly reduce the incidence of CLABSI, enhancing patient safety and reducing healthcare expenditure.

Keywords: CLABSI, Prevention, Chlorhexidine, Antibiotic lock, Risk factors

INTRODUCTION

Healthcare-associated infections (HAIs) pose significant threat to patient safety as it's one of the most significant contributors to risk of outbreaks that might disseminate to the entire hospital and community. The United States Centers for Disease Control and Prevention (CDC) defines an HAI as "a localized or systemic condition resulting from an adverse reaction to the presence of an infectious agents or its toxins.[1]

Central Line Associated Bloodstream Infection (CLABSI) is a common hospital associated-confirmed, primary Bloodstream Infection (BSI) that occurs within 48 hours of central line placement. BSIs, are infectious diseases, characterized by the presence of viable microorganisms in the bloodstream that cause an inflammatory response and affect clinical, biochemical, and hemodynamic parameters.[2]

A central venous catheter (CVC), commonly referred to as a central line, is an intravascular device which is a long, thin, hollow tube that terminates at or near the heart. The wide range of indications for intravascular catheters, including the administration of drugs, blood withdrawal, infusion as well as hemodynamic monitoring, demonstrate their important role for modern health care. However, the use of these devices could elevate the risk of BSI due to microorganisms that colonize the exterior of the device or the fluid path whilst being inserted, leading to an infection.[3]

The risk of morbidity, death, extended hospital stays and medical expenses are all markedly elevated in association with CLABSI. Henceforth, CLABSI was subsequently identified as a significant negative impact of using CVCs. Consequently, identifying the risk factors and preventing the infection is of utmost necessity to improve and optimize the patient outcome that requires the health care

professionals to advocate in reducing the incidence of infections.[4]

INCIDENCE

Annual estimation indicated 250,000 bloodstream infections and concluded majority are associated with intravascular devices. Consequently, among all the HAI, CLABSI has the he highest cost burden with an attributed mortality rate of 12%–25%. Over 28,000 fatalities annually and a cost more than $2 billion were attributed to CLABSIs.[5] In comparison to patients with a CVC who was spared a CLABSI and those who experienced had a 36.6% higher chance of dying in the hospital and a 37.0% higher chance of being readmitted. Central line-associated bloodstream infections are frequent, fatal, expensive but preventable.[4]

RISK FACTORS

The risk of developing CLABSI can be exacerbated by an array of factors, including the indefinite traits of patient along with potential modifiable variables attributed to the insertion or maintenance of vascular catheters.[6]

Intrinsic factors

Age

Children, especially newborns, have a higher incidence of CLABSIs than adults. According to studies, the incidence rate of 6.06 CLABSIs within the first ninety days following placement was highest in pediatric intensive care units. CLABSIs are the primary concern of hospital prevention due to their reported mortality rate of up to 35% and the 14,000–28,000 linked deaths in children each year.[7] According to Dudeck the pooled mean CLABSI rate for infants weighing less than 750 g was 3.4 per 1,000 catheter days.[8]

Gender

In a multicenter study, Kritchevsky et al, identified male gender as a factor associated with increased risk of CLABSI.[9] Another study conducted by Cohen et al, investigated impact of gender differences in bloodstream infections and concluded males are at higher risk of infection due to variation in the propensity to colonize the skin.[10]

Comorbidities

Individuals with several underlying illnesses such as Hematological and immunological deficiencies, Cardiovascular diseases, Gastrointestinal diseases.[11] often has weakened immune systems, subsequently raising their risk of CLABSI.[12]

Extrinsic factors

Prolonged hospital confinement

Cabrero et al conducted a study to investigate risk factors for CLABSI and it showed CLABSI is more likely to occur with prolonged catheterization. The outcome of the study was compared to catheters indwelling for less than 14 days and indicated that a considerably higher number of participants had catheters indwelling for ≥14 days. According to reports, there is a 1.8-fold higher chance of CRBSI hospitalization prior to CVC implantation if the catheterization is prolonged by one day.[11]

Multiple vascular and multi-lumen catheters

Almuneef et al found a tenfold increase in CLABSI risk in pediatric ICU patients with multiple CVCs.[7] More recently, a research implied that the adjusted hazard ratio for CLABSI increased four times for every additional lumen. As pathogens enter the catheter via connectors, risk is proportional to number of entryways.[13]

Parenteral nutrition administration

Fonseca et al carried out a study that revealed there was a higher probability of CLABSI in adult patients receiving total parenteral nutrition (TPN). The American Society for Parenteral and Enteral Nutrition (ASPEN) has established guidelines associating TPN with the risk of CLABSI due to affinity of pathogen for dextrose.[14]

Femoral / internal jugular/ subclavian access site

The Insertion of the CVC can be done via the Subclavian (SC), Internal Jugular (IJ), or Femoral (F) vein. Femoral vein is preferred only under potentially lifesaving circumstances due to higher complication rate.[7] According to Toor et al, predominance of CLABSI was identified with femoral site. Following their removal, the infection rate fell to 0.9 per 1,000 central line days.[15] Study conducted by Timsitet al, conveyed that the internal jugular approach is associated with significantly growing proportion of skin organism and subsequent infection rates, thus concluded subclavian approach is preferred for CVC insertion.[16]

PREVENTION

A bundle is a structured set of evidence-based interventions implemented collectively and reliably for a defined patient population to improve quality of care and patient outcome. Prevention of CLABSI emphasize on utilization of two bundles namely, insertion and maintenance bundle. The implementation of all the interventions together ensured optimal outcome and significant reduction in CLABSI than when implemented individually.[17]

Hand hygiene

The fundamental approach to minimize the risk of CLABSI is associated with direct contact of the hands of health care professional. Myatra et al evaluated the impact of hand hygiene on the risk of health care–associated infections and concluded 31% reduction in CLABSI but rates were still high which emphasized need to include education programme among health care professionals.[18]

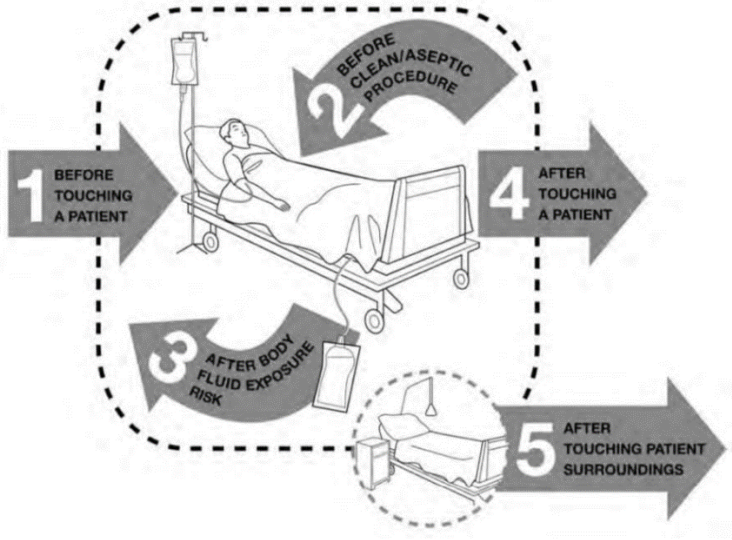

Figure 1: World Health Organization's "My 5 moments for hand hygiene".[19]

CVC insertion preparation

Maximal sterile barrier

The International Nosocomial Infection Control Consortium (INICC) study team created a thorough, international model that assessed the increase in ICU adherence to MSB precautions from 45% to 85%. CLABSI rates decreased, falling by a total of 54% from baseline.[22] Another study introduced an educational program for medical students in an effort to standardize CVC insertion procedures, specifically MSB precautions. The perceived need for full body coverings improved from 22% to 73% after education. Prior to the education, there were 4.51 infections per 1,000 patient days; 18 months later, there were 2.92 infections per 1,000 patient days.[23]

Skin preparation

A meta-analysis of more than 4,000 catheters found that the use of chlorhexidine reduced the risk of bloodstream infection in a secure, convenient and economical manner by almost 50% when compared to the use of povidone-iodine.[24] An economic analysis suggested that using chlorhexidine rather than povidoneiodine would result in a 1.6% decrease in CLABSIs and a 0.23% decrease in mortality, as well as save $113 per catheter used. Chlorhexidine is the ideal antiseptic and is opted over povidone iodine due to prolonged antimicrobial activity and lack of inactivity on exposure to blood and serum.[25] A combination of alcohol with chlorhexidine (chlorhexidine tincture) has a synergistic antibacterial effect against bacteria due to quick bactericidal activity of alcohol.

Studies has emphasized the significance of enabling chlorhexidine to completely dry before to CVC placement.[26]

Catheter kits

A randomized controlled prospective trial evidently confirmed that providing a prepackaged all-inclusive kit is a convenient measure that prevent the complications and errors in the central line catheter insertion procedure.[28] Standardized supply carts assembled by health care organizations, with all the necessary CVC insertion care supplies and equipment placed in "ready to go location" should be checked for correctness, convenience, accessibility and sufficient storage (sterile drape, mask, gloves, cap, chlorhexidine etc.).[21]

Catheter selection

Studies has assessed the effectiveness of implementing antiseptic/antiseptic coated CVCs for preventing CLABSIs which showed better clinical efficacy and economic efficiency, with an additional observed benefit of less vancomycin use.[29] The use of chlorhexidine/silver sulfadiazine or minocycline/rifampin impregnated CVCs was associated by Shorr et al with savings with nearly $10,000 in cost savings per CLABSI that was prevented as a result of the catheters.

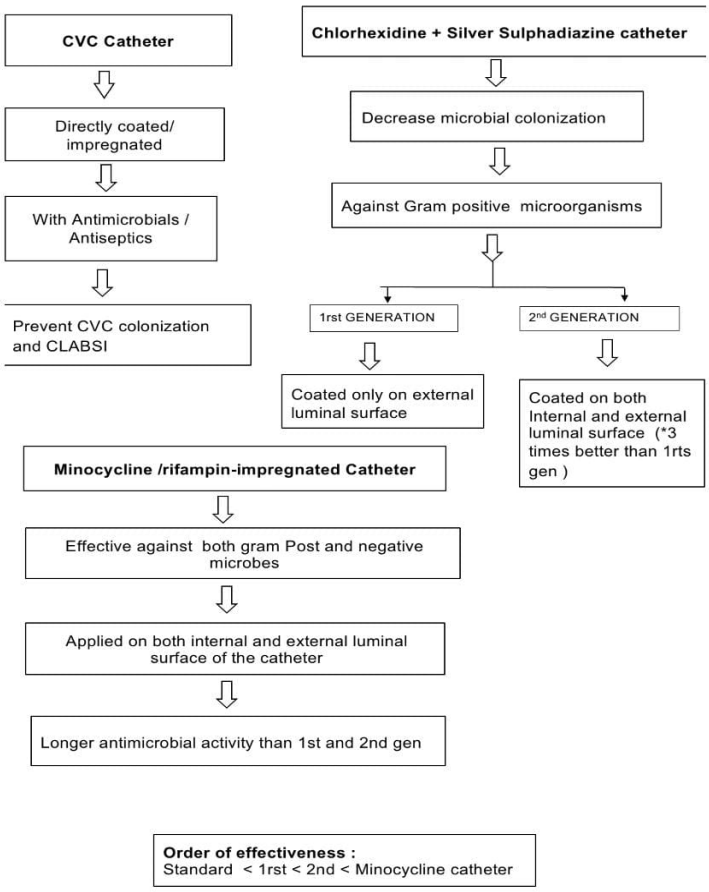

Figure 2: Impregnated Catheter.[20,29-31]

CVC insertion

Site selection

A multitude of complications are linked to femoral vein catheterization .The subclavian approach remains better due to increased patient comfort, and lower potential for infection.[32] However in hemodialysis patients , due to the potential for subclavian vein stenosis , internal jugular vein catheterization is relatively safe and efficient .A randomized controlled study demonstrated reduction in the number of insertion, mechanical complications and decrease in CLABSIs when ultrasound guidance was used.[27]

Securement devices

Suture less device at CVC entry site is preferred as it reduce skin disruption, phlebitis, colonization at insertion site and CVC dislodgement.[20,27]

Catheter site dressing regimen

A multicenter experiment revealed that patients who received dressings impregnated with chlorhexidine experienced significantly lower CLABSIs than those in the control group with a standard dressing.[33]

Table 1: Types of catheter dressing.[33]

Sterile gauze and tape dressing	Transparent polyurethane dressing	Chlorhexidine Dressing
Recommended only if patient is diaphoretic or the insertion site is oozing blood.	Recommended mostly as it allows visual inspection of infection site and secure the device properly.	Recommended choice for maximum infection risk reduction due to its long-lasting bactericidal and pharmacokinetic s. properties.
Replace every 2 days.	Replace every 7 days.	Replace every 7 days.

CVC maintainance

Studies showed implementation of the post insertion bundle, reduced the CLABSI rate significantly. Compliance with the CLABSI maintenance bundle has

been shown to be a significant predictor of improvement in the CLABSI rates.[34]

Catheter lock and flushing

Locking is a procedure that involves instillation of a concentrated antimicrobial solution into the catheter lumen until it is filled, which is then allowed to remain within a specific period of time, with the intention to attain a sustained level of drug for eradicating the microbes within the biofilm of the catheter.[20] Catheter flushing is a procedure in which the solution is forced through the catheter directly into the bloodstream. Due to the critical role of long term CVC in current healthcare system, it emerged as a significant alternative for the preventive and complementary therapy of CLABSI. A broad range of antibiotics have been studied for clinical application; vancomycin and gentamicin have been used most frequently.[35]

Disinfection of catheter hubs, connectors and injection ports

Solution of 70% alcohol and chlorhexidine is used to disinfect catheter hubs, connectors and injection ports from pathogen entry into the intraluminal surface of the catheter. Certain factors associated are amount of contact time between the surface and the antiseptic agent,method of application and higher the concentration, faster the action of disinfectant. A prospective study demonstrated that novel devices like antiseptic barrier cap and silver-coated needleless connectors is highly effective in eradicating microorganisms.[39]

Table 2: Ideal properties of catheter lock solution and its specific volume with different devices.[35]

S. no.	Properties	
1.	An ideal antimicrobial lock or flush solutions Has broad spectrum activity. Penetrate biofilm against multidrug resistance gram positive and negative microbes . Prevent colonization at internal luminal surface CVC and used in patients with long term catheter and recurrent CLABSI Cost-effective and low risk of toxicity and adverse events. Range of dwell time is 4-24 hours and duration is 7 to 14 days. Activity enhanced with ion chelators like EDTA , citrate .	
2.	Specific catheter lock volumes associated with each device :	
3.	Device	Approximate volume of lumen
4.	Tunneled Cuffed Central Venous Catheter	2 ml
5.	Peripherally inserted central venous catheter (PICC)	1 ml
6.	Totally implantable Venous Port Device	2 ml
7.	Hemodialysis catheter	To the length of the individual lumen

Table 3: Commonly used antibiotics lock solution.

Antibiotics	Concentration (mg/ml)	Heparin concentration	Additives	Dwell duration (hours)
Vancomycin	5	5,000 units/ml	0.9 % NaCl 4.2 % Citrate*	6-24 6-48
Gentamicin	1	No compatibility	0.9 % NaCl 4.2 % Citrate*	6-24 6-48
Amikacin	2	No compatibility	0.9 % NaCl	6-24
Ampicillin	10	5,000 units/ml	0.9 % NaCl	6-24
Ciprofloxacin	0.125	≤2,500 units	0.9 % NaCl	6-24
Linezolid	0.2–1.92	10,000 units/ml	0.9 % NaCl	6-24
Teicoplanin	2	10,000 units/ml	0.9 % NaCl	6-24
Cefazolin	10	5,000 units/ml	0.9 % NaCl	6-24

*For hemodialysis patients. (NaCl: Sodium Chloride).[36-38]

Table 4: Summary of CLABSI prevention care bundle.

Procedure	Bundle rationale
Hand hygiene	Cleanse prior to and after palpating the site of catheter insertion. Cleanse before and after inserting the catheter Cleanse prior and after accessing, replacing, repairing, or dressing the catheter [20]

Continued.

Procedure	Bundle rationale
CVC insertion preparation	Maximal barrier precautions require CVC inserter to put on a mask, cap, sterile gown, and sterile gloves while covering the patient from head to toe in a large sterile drape.[21] Chlorhexidine skin cleansing and preparation: •Prior to insertion, apply a solution of alcohol and chlorhexidine that is concentrated at a level > 0.5%. •Alternatives like tincture of iodine or alcohol can be applied if chlorhexidine is contraindicated.[20,26] •Let the antiseptic solution to dry. •Sterilize the hubs, connectors, and injection as well.[27]
	Use CVC with minimum number of ports or lumens. Use antimicrobial or antiseptic-impregnated catheters.
CVC insertion	
Site selection	Avoid using the femoral site for CVC access in adult patients. Use a subclavian site rather than a jugular site Avoid subclavian site in hemodialysis patients.[32] Use of ultrasound guidance to place CVCs.[27]
Site dressing regimen	Chlorhexidine is the most preferred choice for dressing
Securement device	Use suture less devices
CVC maintenance	Daily assess the CVC line necessity. Evaluate signs of redness, pain, swelling, systemic infection suture and dressing integrity and patency of lumen. Perform site care with chlorhexidine at dressing change Evaluate catheter position, change gauze dressing every 2 days and clear dressings every 7 days. Within 24 hours of infusion, replace blood administering tubing. Ensure prompt removal of CVCs. Utilize a standardized CVC checklist to enhance adherence.[34] Use needleless system like split septum to access IV tubing. Ensure compatible system to minimize leaks and breaks.[39]

Chlorhexidine bathing

A chlorhexidine impregnated washcloth can be used as a total body bathing solution to reduce skin contaminants that can enter bloodstream at CVC insertion site and hence reduce CLABSI rate. Studies has concluded that chlorhexidine bathing was an easy and effective intervention that reduced the rate of CLABSI.[40]

CONCLUSION

In conclusion, central line-associated bloodstream infections (CLABSI) represent significant and preventable healthcare-associated infection that carries substantial morbidity, mortality, and financial costs. CLABSI is most prevalent in specific patient populations, including neonates and those with certain underlying diseases. Preventing CLABSI involves a combination of measures, including proper hand hygiene, catheter insertion preparation, skin preparation using chlorhexidine, catheter kits, selection of appropriate catheters, and maintenance bundles. Additionally, antimicrobial lock and flush solutions are essential in eradicating microbes within catheter lumens. Chlorhexidine bathing is another effective strategy to reduce skin contaminants and lower CLABSI rates. By implementing these evidence-based interventions collectively and reliably, healthcare facilities can significantly reduce the incidence of CLABSI, ultimately improving patient safety and reducing healthcare costs.

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