Central Line Associated Blood Stream Infection Prevention Initiative

Prepared by:

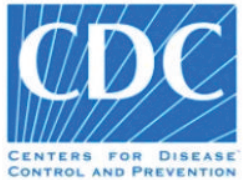
All India Institute of Medical Sciences, New Delhi, India

Centers for Disease Control and Prevention, India

Indian Council of Medical Research, New Delhi, India

As part of the Global Health Security Agenda project entitled

"Capacity Building and Strengthening of Hospital Infection Control to Detect and Prevent Antimicrobial Resistance in India"



Central Line Associated Blood Stream Infection Prevention Initiative

Prepared by:

All India Institute of Medical Sciences, New Delhi, India

Centers for Disease Control and Prevention, India

Indian Council of Medical Research, New Delhi, India

As part of the Global Health Security Agenda project entitled

"Capacity Building and Strengthening of Hospital Infection Control to Detect and Prevent Antimicrobial Resistance in India"

Table of contents

Content **Page number**

1. Background

Central venous catheters (CVCs), often described by healthcare professionals as “central lines,” refer to a broad category of invasive devices used to administer fluids, medications, blood & blood products, and parenteral nutrition. The use of these catheters is associated with an increased risk of blood stream infections (BSIs), which are potentially life threatening. Most of these infections are however preventable by adhering to best practices during insertion and maintenance of these lines.

Prevention of Central line-associated blood stream infections (CLABSIs) represent a complex challenge for the infection control teams and the many stakeholders involved in those prevention activities.

This implementation guide is designed to provide basic information regarding the prevention of CLABSIs that is applicable for use by all infection preventionists (IPs), regardless of their health care setting or their level of experience. The information provided will also help facilitate the learning of basic concepts and provide health care workers with an opportunity to objectively evaluate current practice within the framework of continuous quality improvement activities.

The goal of this implementation guide is to outline practices that are core to prevention efforts, demonstrate application through accompanying tools and resources, and provide information that augments existing evidence-based guidelines.

CVCs access major vessels that are most often located in the neck or adjacent to the heart. There are four general categories of CVCs:

A. Nontunneled (inserted via subclavian or internal jugular veins)
B. Peripherally inserted central catheters (PICCs) inserted via peripheral veins (e.g., cephalic or basilic)
C. Subcutaneously tunneled
D. Implanted vascular access ports.

2. Risks associated with Central line use

Central lines are associated with significant risks:

- Major risk factor for bloodstream infections
- Associated with a 2.27-fold increased risk for mortality
- Increase healthcare costs
- Prolong hospital stays

3. Dissemination of Microbes Due to Central Line Use

In patients with central lines, the dissemination of microbes in the bloodstream can occur via four potential routes. Infection prevention (IP) practices should try to reduce the risk for the routes of spread.

Figure 1 shows the common portals of entry of microbes in blood in a patient with a central line.

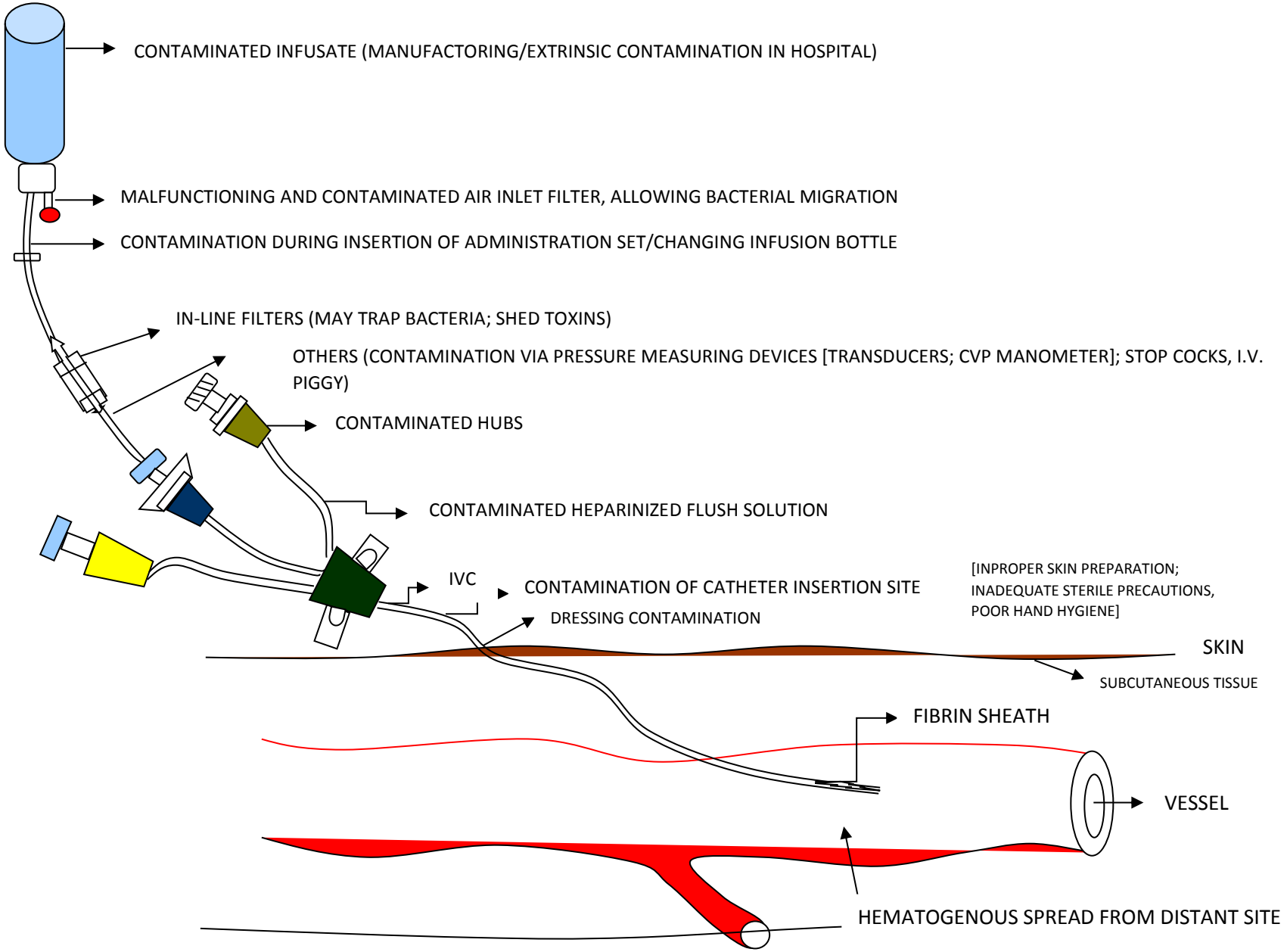


Fig 1: Routes of entry of microbes into blood stream via intravascular devices

i. Hematogenous Spread

Organisms can be carried hematogenously to the indwelling catheter from remote sources of local infection. For example, if a patient with a central line has a documented pneumonia and his/her blood culture grows an organism, the central line is not removed as part of treatment. Due to its rare occurrence, a catheter is usually not removed in the presence of a BSI from a well-documented secondary source.

ii. Intraluminal Spread

Microorganisms can contaminate the catheter hub (and lumen) when the catheter is inserted over a percutaneous guide wire or later manipulated in a variety of ways. For example, repositioning central lines, intravenous administrations etc. Inadequate disinfection of access sites (i.e., needleless connectors), incorrect use of stop cocks and other types of connectors, and inadvertent contamination of intravenous administration sets and tubing provide opportunities for microorganisms to be introduced into an otherwise sterile system. Intraluminal colonization becomes an even more significant clinical risk in the pathogenesis of CLABSI with increasing dwell time. This risk is one of the reasons for the genesis of CLABSI maintenance bundles.

Core measures for reducing the risk of intraluminal contamination

- **Careful and meticulous hand hygiene**
- **Attention to aseptic technique with all infusion-related procedures**
- **Minimal manipulation of the central catheter and adjunct administration components**
- **Rigorous disinfection practices when the system must be manipulated (SCRUB THE HUBS)**

iii. Extraluminal Spread

Extraluminal spread occurs when skin organisms, most commonly coagulase-negative staphylococci and *Staphylococcus aureus*, incite an infection through portals of entry, including

skin at the insertion site and catheter hubs. This is the mostly likely source of an incubating infection for catheters in place for < 14 days.

iv. Contaminated Infusates

Infusates, such as parenteral fluid, blood products, or IV medications are sterile products administered through a vascular access catheter. They can potentially become contaminated and lead to device-associated BSI. Most healthcare-associated ***epidemics*** of infusion-associated BSIs have been traced to contamination of infusate by gram-negative bacilli, introduced during manufacturing (intrinsic contamination) or during preparation and administration in the healthcare setting (extrinsic contamination). This is however an uncommon cause of endemic BSIs.

4. Modifiable Risks

Many CLABSI risk factors can be reduced by careful and consistent use of targeted prevention practices. However, these practices can vary according to situations. For example, although several large veins may support the use of a central catheter, infection risks vary according to insertion site. Thus, femoral sites are associated with a higher risk of infection as compared to subclavian, due to the generally higher contamination of skin at femoral site. Similarly, central catheters placed quickly during an emergency situation have higher risks than those placed electively. Table 1 summarizes the most common modifiable CLABSI risk factors.

Table 1: Modifiable risk factors for CLABSI Prevention

Situation	High Risk	Low Risk
Insertion Circumstances	Emergency	Elective
Skill of inserter	Novice	Specialized
Insertion site	Femoral Vein	Subclavian Vein
Skin antisepsis	70% alcohol; 10% Povidone-iodine	2% chlorhexidine
Catheter lumens	Multi-lumen	Single lumen
Duration of catheter use	Longer duration	Shorter duration
Barrier precautions	Submaximal	Maximal

5. Prevention of CLABSI

CLABSIs may be prevented through proper placement and management of central lines. Evidence-based central line insertion practices known to reduce the risk of CLABSIs include hand hygiene by inserters, use of maximal sterile barriers during insertion, proper use of a skin antiseptic prior to insertion, and time to allow the skin antiseptic to dry before catheter insertion. Research indicates that 65-70 percent of CLABSIs are preventable by implementing evidence-based strategies currently available to healthcare professionals. In comparison to other healthcare-associated infections, CLABSIs are associated with the highest number of preventable deaths. The Institute for Healthcare Improvement (IHI) introduced its ***first bundle of prevention practice for CLABSI reduction*** in the past decade. The use of preventive bundles has been associated with a sustained decrease in the incidence of CLABSI globally.

The IHI defines a bundle as a small set of evidence-based interventions for a defined patient population and care. The CLABSI bundle identified a group of interventions supported by the highest level of research, which when used together would ideally produce better outcomes than if one or more had been used separately.

The practices described in the IHI CLABSI bundle include:

- ***Hand hygiene***
- ***Maximal sterile barrier precautions upon insertion***
- ***Chlorhexidine skin antisepsis***
- ***Optimal site selection (avoidance of femoral vein in adults)***
- ***Daily review of central line necessity and prompt removal of unnecessary lines***

These five evidence-based interventions remain the cornerstone of CLABSI prevention, especially at the time of catheter insertion.

Figure 2

Central line insertion bundle: cornerstone of CLABSI

6. Alternatives for Resource-limited situations

1. Hand Hygiene: This is an essential practice and must be done before a central line insertion, in whichever type of health care facility the procedure is being undertaken.
2. Maximum sterile barrier (MSB) precautions: These are defined as wearing a sterile gown, sterile gloves, and cap and using a full body drape (similar to the drapes used in the operating room) during the placement of CVC. Use of MSB is associated with fewer episodes of both catheter colonization and CLABSIs. If infections occur, they are seen much later with use of MSB. However, in situations where full body drape of patient is not possible, a less ideal alternative is using four small sterile drapes (as shown in Figure 3 below), leaving a small opening for catheter insertion.

Figure 3: Using four drapes if a full body drape is not available

3. Optimal catheter site selection: The site at which a catheter is placed influences the subsequent risk for catheter-related infection and phlebitis. Femoral catheters should also be avoided, when possible, because they are associated with a higher risk for deep venous thrombosis than are internal jugular or subclavian catheters and higher microbial colonization.

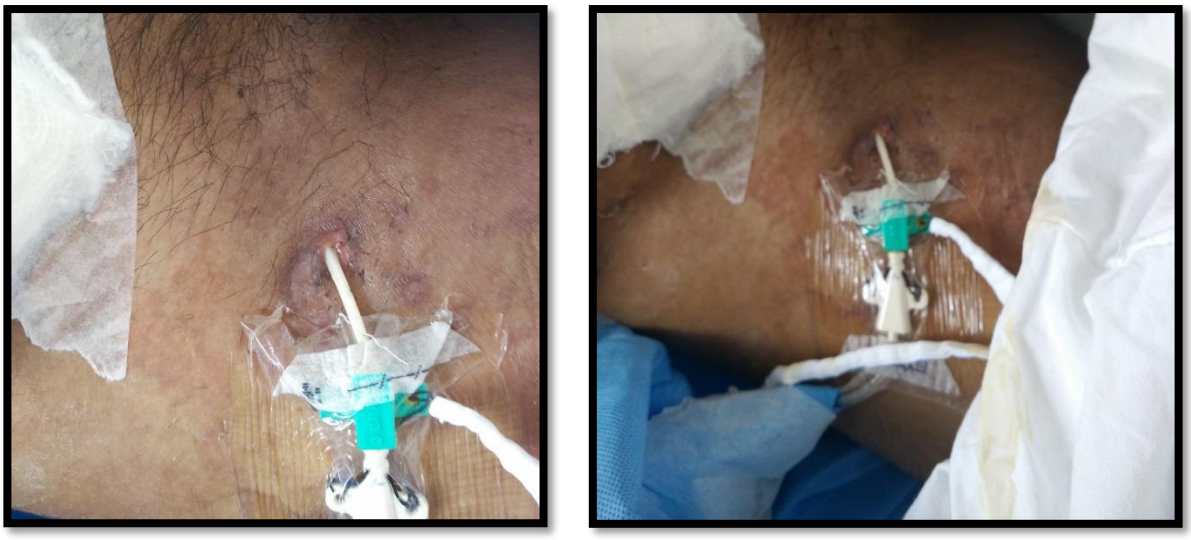


Figure 4: Avoid Femoral Line Insertions

4. Daily review necessity of lines: The presence of a central line in-situ is the biggest risk factor of CALBSI. Thus, there is no substitute for this extremely critical activity of daily review of the necessity to keep a central line.
5. Chlorhexidine skin antisepsis: It is advisable to prepare clean skin with a >0.5% chlorhexidine preparation with alcohol before a CVC insertion and during dressing changes. If there is a contraindication to chlorhexidine, tincture of iodine, an iodophor, or 70% alcohol can be used as alternatives. Chlorhexidine-containing cutaneous antiseptic regimen have shown lower rates of catheter colonization or CLABSIs as compared with either povidone iodine or alcohol.

7. Recommendations for prevention of IV catheter associated infections

The CDC and HICPAC has provided evidence based recommendations for prevention of IV catheter related infections. The system for categorizing recommendations is as follows:

- Category IA. Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies.
- Category IB. Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale; or an accepted practice (e.g., aseptic technique) supported by limited evidence.
- Category IC. Required by state or federal regulations, rules, or standards.
- Category II. Suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale.

Table 2 gives the current category I and II recommendations of the CDC for prevention of CLABSIs

Table 2: CDC's Category I/II recommendations for prevention of CLABSI

Education, Training and Staffing	Category
Educate healthcare personnel regarding the indications for IV catheter (IVC) use, proper procedures for the insertion and maintenance, and appropriate infection control measures to prevent IVC -related infections.	IA
Periodically assess knowledge of, and adherence to, guidelines for all personnel involved in insertion/maintenance of IVCs.	IA
Designate only trained personnel for insertion/maintenance of IVCs.	IA
Ensure appropriate nursing staff levels in ICUs.	IB
Selection of Catheters and Sites	
Adults: Upper-extremity site. Replace a catheter inserted in lower extremity to an upper extremity site as soon as possible.	II
Pediatrics: Upper/lower extremities or the scalp (in neonates or young infants) can be used.	II
Select catheters on the basis of the intended purpose and duration of use, known infectious and non-infectious complications & experience of individual catheter operators.	IB
Avoid use of steel needles for the administration of fluids and medication that might cause tissue necrosis if extra vasation occurs.	IA
Use a midline catheter or PICC, instead of a short peripheral catheter, when the duration of IV therapy will likely exceed six days.	II
Evaluate the catheter insertion site daily by palpation through the dressing to discern tenderness and by inspection if a transparent dressing is in use. Gauze and opaque dressings should not be removed if the patient has no clinical signs of infection. If the patient has local tenderness or other signs of possible CLABSI, an opaque dressing should be removed and the site inspected visually.	II
Remove peripheral venous catheters if the patient develops signs of phlebitis, infection, or malfunctioning catheter.	IB
Central Venous Catheters	
Weigh the risks/benefits of placing a CVC at a recommended site to reduce infectious complications against the risk for mechanical complications.	IA
Avoid using the femoral vein in adult patients.	1A
Use a sub clavian site, rather than a jugular or a femoral site, in adult patients for non-tunneled CVC.	IB
Avoid the subclavian site in hemodialysis patients and patients with advanced kidney disease.	IA
Use a fistula/graft in patients with chronic renal failure instead of CVC for permanent access for dialysis.	1A
Use ultrasound guidance to place CVCs (if this technology is available); only to be used by those fully trained in its technique.	1B
Use a CVC with the minimum number of ports or lumens.	IB
Promptly remove any intravascular catheter that is no longer essential.	IA
When adherence to aseptic technique cannot be ensured (i.e. catheters inserted during a medical emergency), replace the catheter as soon as possible, i.e. within 48 hours.	IB
Hand Hygiene and Aseptic Technique	
Perform hand hygiene procedures, either by washing hands with conventional soap and water or with alcohol-based hand rubs (ABHR). Hand hygiene should be performed before and after palpating catheter insertion sites as well as before and after inserting, replacing, accessing, repairing, or dressing an IVC. Palpation of the insertion site should not be performed after the application of antiseptic, unless aseptic technique is maintained.	IB

Maintain aseptic technique for the insertion and care of intravascular catheters.	IB
Sterile gloves should be worn for the insertion of arterial, central, and midline catheters.	IA
Use new sterile gloves before handling the new catheter when guide wire exchanges are performed.	II
Wear either clean or sterile gloves when changing the dressing on intravascular catheters.	IC
Maximal Sterile Barrier Precautions	
Use maximal sterile barrier precautions, including the use of a cap, mask, sterile gown, sterile gloves, and a sterile full body drape, for the insertion of CVCs, PICCs, or guide wire exchange.	IB
Use a sterile sleeve to protect pulmonary artery catheters during insertion.	IB
Skin Preparation	
Prepare clean skin with an antiseptic (70% alcohol, tincture of iodine, an iodophor or chlorhexidine gluconate) before peripheral venous catheter insertion.	IB
Prepare clean skin with a 0.5% chlorhexidine preparation with alcohol before central venous catheter and peripheral arterial catheter insertion and during dressing changes. If there is a contraindication to chlorhexidine, tincture of iodine, an iodophor, or 70% alcohol can be used as alternatives.	IA
Antiseptics should be allowed to dry according to the manufacturer's recommendation prior to placing the catheter.	IB
Catheter Site Dressing Regimens	
Use either sterile gauze or sterile, transparent, semipermeable dressing to cover the catheter site.	IA
If the patient is diaphoretic or if the site is bleeding or oozing, use a gauze dressing until this is resolved.	II
Replace catheter site dressing if the dressing becomes damp, loosened, or visibly soiled.	IB
Do not use topical antibiotic ointment or creams on insertion sites, except for dialysis catheters, because of their potential to promote fungal infections and antimicrobial resistance.	IB
Do not submerge the catheter or catheter site in water. Showering should be permitted if precautions can be taken to reduce the likelihood of introducing organisms into the catheter (e.g., if the catheter and connecting device are protected with an impermeable cover during the shower).	IB
Replace dressings used on short-term CVC sites every 2 days for gauze dressings.	II
Replace dressings used on short-term CVC sites at least every 7 days for transparent dressings, except in those pediatric patients in which the risk for dislodging the catheter may outweigh the benefit of changing the dressing.	IB
Replace transparent dressings used on tunneled or implanted CVC sites no more than once per week (unless the dressing is soiled or loose), until the insertion site has healed.	II
Ensure that catheter site care is compatible with the catheter material.	IB
Use a sterile sleeve for all pulmonary artery catheters.	IB
Use a chlorhexidine-impregnated sponge dressing for temporary short-term catheters in patients older than 2 months of age if the CLABSI rate is not decreasing despite adherence to basic prevention measures.	1B
Monitor the catheter sites visually when changing the dressing or by palpation through an intact dressing on a regular basis. If patients have tenderness at the insertion site, fever without obvious source, or other manifestations suggesting local or bloodstream infection, the dressing should be removed to allow thorough examination of the site.	IB
Encourage patients to report any changes in their catheter site or any new discomfort to their provider.	II
Patient Cleansing Use a 2% chlorhexidine wash for daily skin cleansing to reduce CLABSI.	II

8. A pictorial guide of interventions to reduce CLABSI

The following pictures illustrate the interventions which have scientifically proven to reduce the risk of CLABSIs. The teaching videos of various activities pertaining to CLABSI prevention will be uploaded on the project website and the soft copies will be provided in pen drives.

Figure 5: Articles required for Central line insertion

Figure 6: Personal Protective Equipmen to be used for Central line insertion

Figure 7: Hand hygiene: The most important pre-requisite

Figure 8: Method of putting on sterile gown

Figure 9: Method of putting on sterile gloves

Figure 10: Site selection for Central line insertion

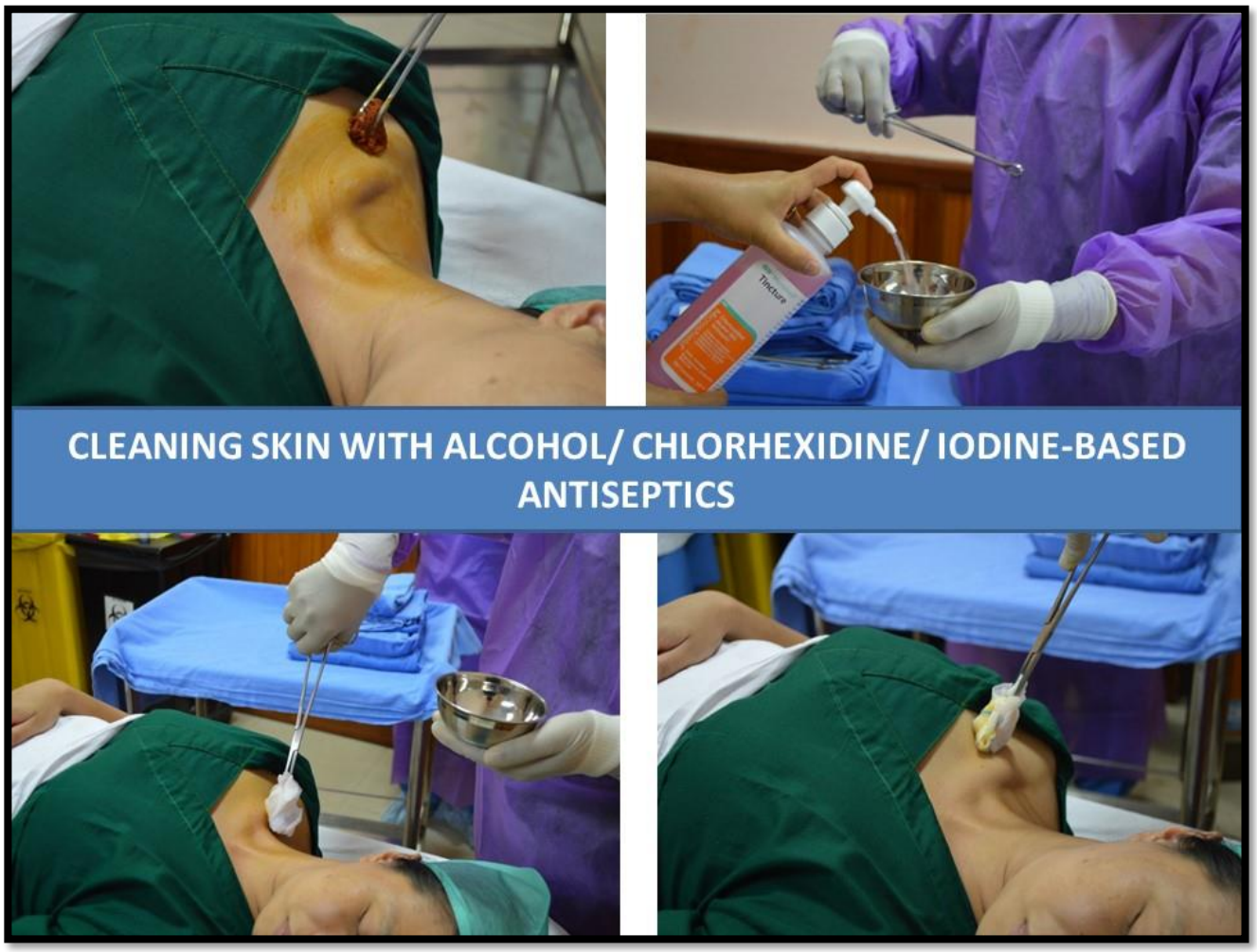


Figure 11: Steps of skin preparation for central line insertion

Figure 12: Method of full draping for CVC insertion

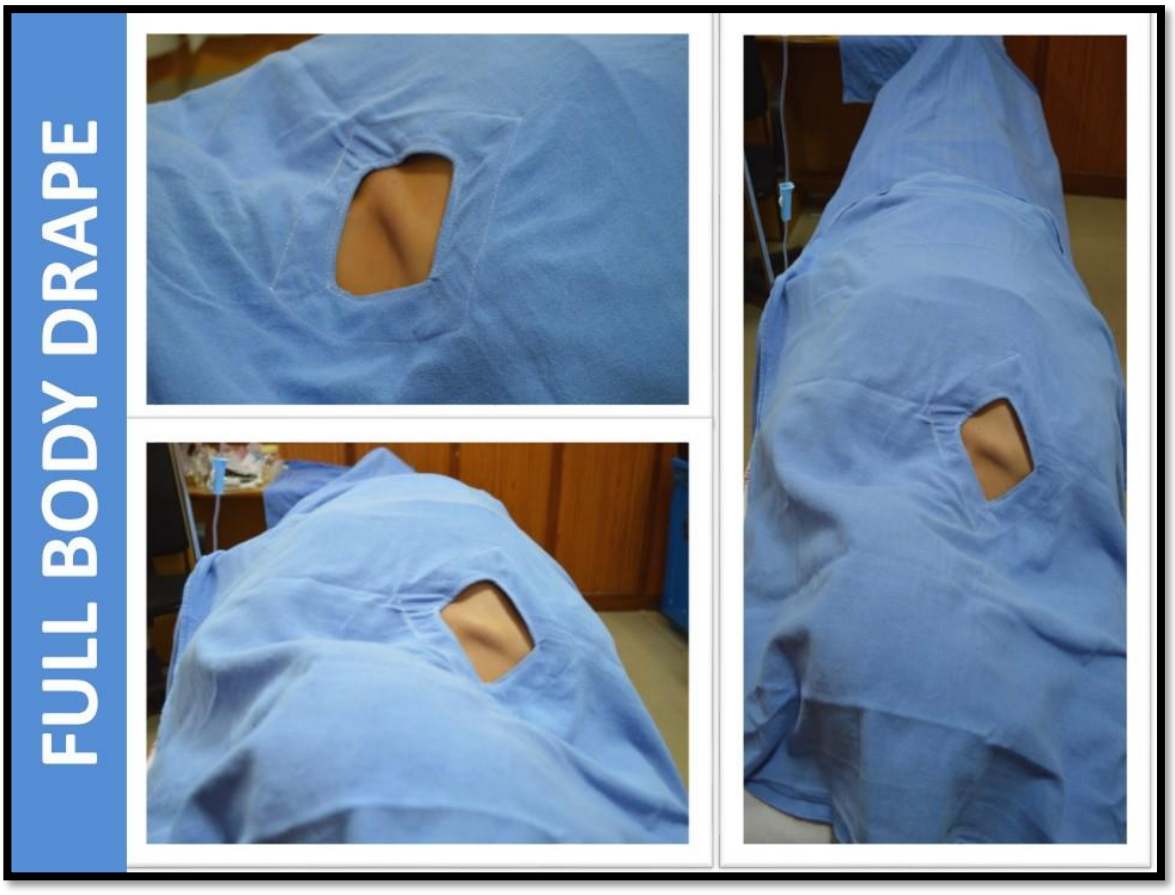
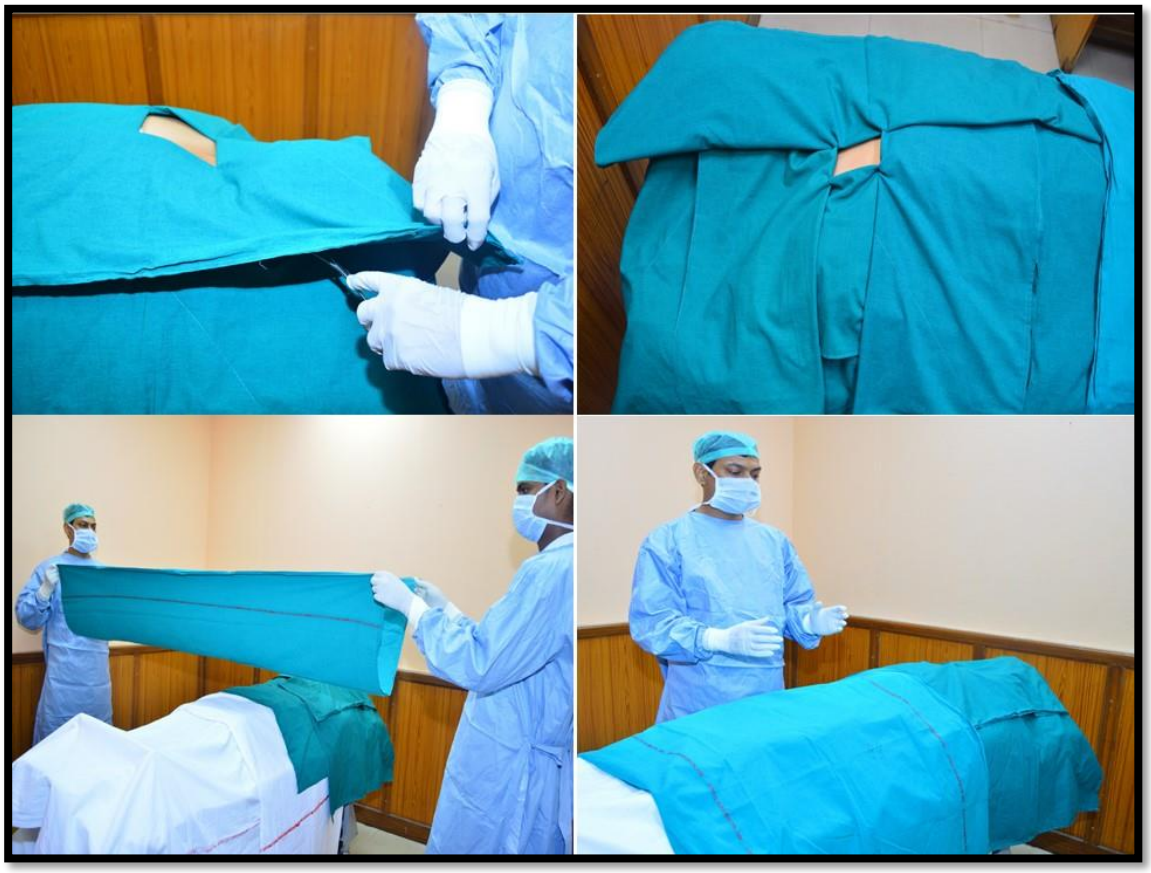


Figure 13: Method of draping using sterile towels



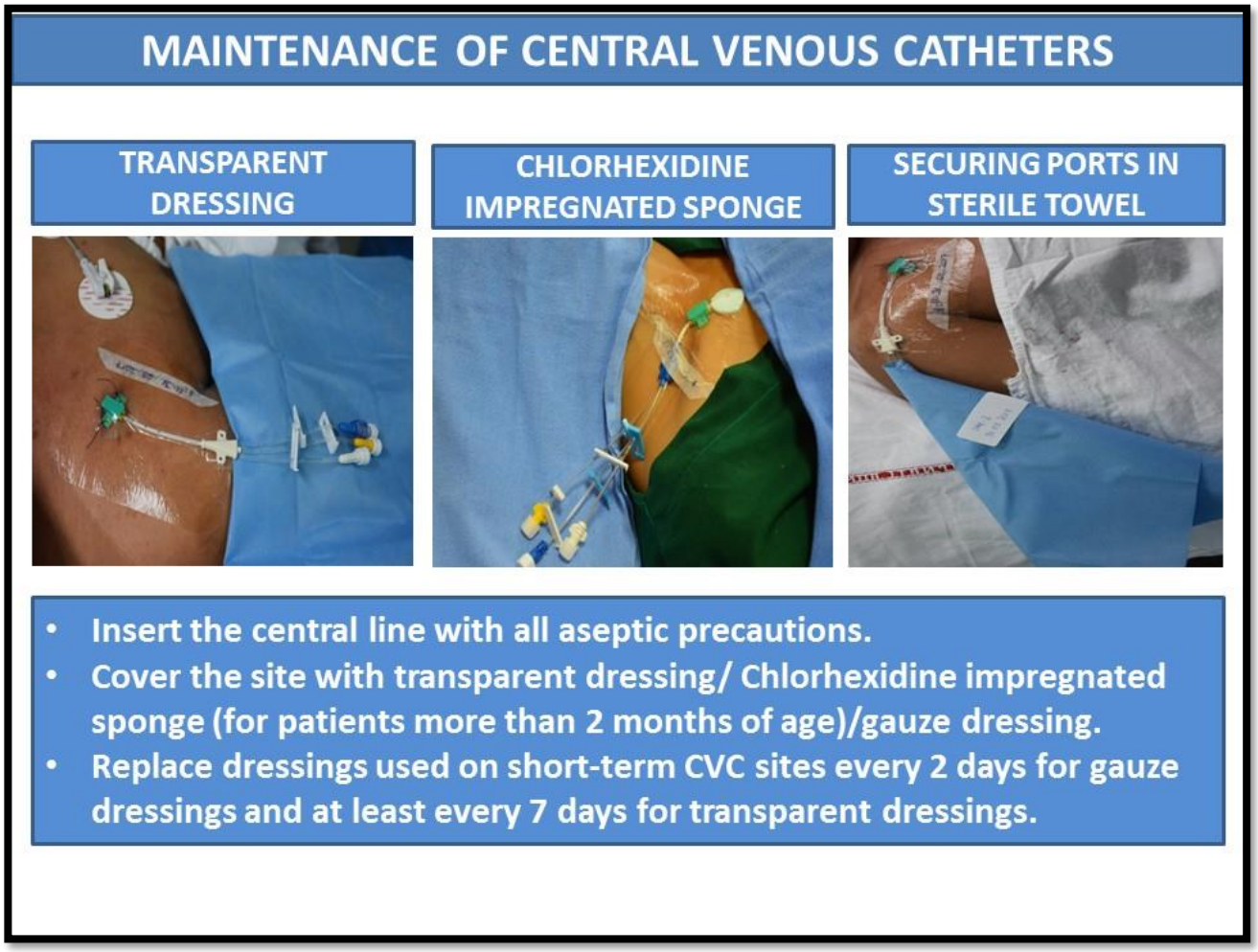


Figure 14: Central line maintenance

9. Monitoring of adherence to CLABSI preventive practices

To promote CLABSI prevention, the use of checklists and the promotion of safety culture are important. The prevention program adopted by any facility that provides healthcare should show significant improvements but also needs to be sustainable. Wide dissemination and training on the current proven and readily accessible materials help in improving practices and reducing the rates of CLABSI. Use of an evidence-based bundle of interventions can improve patient outcomes only if the interventions are consistently completed. Ongoing monitoring is needed to ensure adherence to elements of the bundle. The outcome improvement must be documented in a clear, consistent manner and reported according to specific criteria. The initial set of bundled CLABSI prevention practices have been widely adopted and often used in combination with an insertion checklist. However, the terms “bundle” and “checklist” are not interchangeable. A checklist can be used to supplement a bundle and is most effective when used as part of a broader, more comprehensive approach to patient safety. The checklist usually includes additional practices, some of which may not be based on level I evidence and may, in certain instances, be optional. In 2013, the Agency for Healthcare Research and Quality named bundles that include checklists to prevent CLABSI one of the top 10 “strongly encouraged patient safety practices.”

10. Central Line Insertion Practices (CLIP) Toolkit

Overview of CLIP Toolkit

The following resources are included in the Central Line Insertion Practices (CLIP) Resource Toolkit:

1. **CLIP Toolkit Introduction**: Provides a brief introduction to evidence based central line insertion practices (CLIP), and an overview of CLIP adherence monitoring.

2. **CLIP Toolkit Monitoring Form and Instructions:** Data collection tool used to conduct central line insertion observations.

3. **CLIP Toolkit Database and Instructions**: Excel database used for entering and analyzing CLIP adherence monitoring data. The database accompanies this CLIP Toolkit document.

4. **CLIP Toolkit Facility Data Report Template and Instructions**: Facility level data report template; this report should be shared with hospital IPC committee monthly.

5. **CLIP Toolkit Central Data Report Template and Instructions**: Central level data report template, this report should be sent to the central database manager monthly.

CLIP Toolkit Introduction

Healthcare facilities have found it useful to monitor adherence to evidence-based central line insertion practices as a method for identifying quality improvement opportunities and strategically targeting interventions. Feedback of adherence data has been a component of multifaceted interventions that have successfully reduced CLABSI rates.

Participation in monitoring adherence to central line insertion practices enables facilities to:

- Review central line insertion practices in individual patient care units and facilities and provide aggregated adherence data for all participating facilities across a network.
- Facilitate quality improvement by identifying specific gaps in adherence to recommended prevention practices, thereby helping to target intervention strategies for reducing CLABSI rates.

Participating facilities should perform surveillance for central line insertion practices at the same time as CLABSI surveillance in order to identify associations between insertion practices and CLABSI incidence. Only central lines inserted for temporary use are included in this monitoring tool.

Persons Involved: The form should be completed by a trained infection prevention and control staff member with clinical training who is assigned to the surveillance unit conducting monitoring of adherence to central line insertion practices. The observer should be present for every central line insertion procedure for which a form is completed. The form should not be completed by the inserter or a person assisting with insertion.

Numerator and Denominator Data: The Central Line Insertion Practices Adherence Monitoring Form is used to collect and report central line insertion practices for every central line insertion attempt, including unsuccessful attempts, occurring during the month in the unit(s) selected for surveillance. The table at the end of this document lists instructions for collection and entry of each element on the form.

The form includes information pertaining to demographics of the patient, information pertaining to the inserter, information on maximal sterile barriers used, the reason for central line insertion, skin antisepsis,hand hygiene practice before insertion, and location of insertion site. Elements of these data will be used to calculate adherence to recommended insertion practices.

Some central line may be inserted during hours in which infection control staff might not be available to observe the insertions. Measuring the percentage of central line insertions that were observed is useful to determine how well the findings from observed insertions represent all completed insertions.

Data Analyses: Adherence rates for specific insertion practices will be calculated by dividing the number of central line insertions during which the recommended practice was followed by the total number of observed central line insertions and multiplying the result by 100. For example if the rates of hand hygiene

is to be calculated in 50 central lines insertions monitored and hand hygiene was practiced in 48 of them, the rate of adherence is:

48/50 x100= 96%

Such calculations can also be done for a bundle of practices that have been shown to reduce the incidence of CLABSI. For example there were a total of 50 CLIs observed in a unit. Of these, there 20 central lines were inserted following all bundle elements. Thus, the rate of adherence is:

20/50 x 100

20/50= 0.4 x 100= 40 % of central lines were inserted following all elements of CLABSI bundle

Measured adherence to the bundle requires a "Yes" to all of the following:

- **Hand hygiene performed**
- **Appropriate skin prep**
    - **Chlorhexidine gluconate (CHG) for patients ≥ 60 days old unless there is a documented contraindication to CHG**
    - **Povidone iodine, alcohol, CHG, or other specified for children < 60 days old**
- **Skin prep agent has completely dried before insertion**
- **All 5 maximal sterile barriers used**
    - **Sterile gloves**
    - **Sterile gown**
    - **Cap**
    - **Mask worn**
    - **Sterile full body drape**

Note: These calculations are performed separately for different types of locations in the institution.

CLIP Toolkit Monitoring Form

Section A. General information

1. Facility ID: _____ 2. Surveillance ID: _____

3. Patient ID: _____

4. Date of observation: ___ /___ /_____ (DD/MM/YYYY) 5. Event #: _____

6. Name of observer: _____

7. Occupation of inserter:

□ Medical student □ Intern/resident □ Consultant physician □ Other medical staff

8. Reason for insertion:

□ New indication for central line (e.g., hemodynamic monitoring, fluid/medication administration, etc.)

□ Replace malfunctioning central line □ Other (specify): _____

□ Suspected central line-associated infection

Section B. Summary of insertion practices

9. Insertion site: □ Femoral □ Jugular □ Subclavian □ Umbilical □ Other

10. Insertion completed? □ Yes □ No

11. Inserter performed hand hygiene prior to central line insertion? □ Yes □ No

Which of the following barriers were used:

12a. Mask	12b. Sterile gown	12c. Sterile gloves	12d. Cap	12e. Full body sterile drape
□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No

13. Skin preparation agent was used (select Yes or No based on patient age):

If patient age < 60 days: was chlorhexidine gluconate, povidone iodine, or alcohol used?
If patient age ≥ 60 days: was chlorhexidine gluconate used? □ Yes □ No

14. Was skin preparation agent completely dry at time of first skin puncture? □ Yes □ No

Instructions for completing the CLIP Toolkit Monitoring Form

Use the table below to complete the form.

Data Field	Instructions
Facility ID	Required. Enter the number for the facility assigned by the network.
Surveillance ID	Required. Enter the number for the surveillance unit at the facility assigned by the network.
Patient ID	Required. Enter the alphanumeric patient ID number. This is the patient identifier assigned by the hospital and may consist of any combination of numbers and/or letters.
Date of observation	Required. Enter the date the central line insertion was observed (DD/MM/YYYY).
Event #	Required. Should be generated as follows: Facility ID – Surveillance ID – Date of insertion (DDMMYYYY) – Serial number of insertion Example: The third central line inserted on 1 December 2016 in an ICU with Surveillance ID 5 at a hospital with Facility ID 2 would be 2 – 5 – 01122016 – 3
Name of observer	Required. Record the first and last name of the person observing the central line insertion procedure.
Occupation of inserter	Required. Check the occupational category of the person inserting the central line.
Reason for insertion	Required. Check the primary reason for inserting the central line: New indication (e.g., hemodynamic monitoring, fluid/medication administration, etc.); Replace malfunctioning central line; Suspected central lineassociated infection. If Other, please specify.
Insertion site	Required. Check the site of insertion of the central line.
Insertion completed	Required. Check Yes if the insertion was completed, check No if the insertion was not completed?
Inserter performed hand hygiene prior to central line insertion?	Required. Check Yes if the inserter appropriately performed hand hygiene prior to inserting central line; otherwise check No. Appropriate hand hygiene includes the use of alcohol-based hand rub or soap and water hand wash. If not observed directly, ask inserter.
Which of the following barriers were used?	Required. Indicate whether each of the 5 barriers was used appropriately, by checking Yes or No. NOTE: If inserter wore either a mask or a mask with eye shield, the Yes box for Mask should be checked.
Skin preparation was used.	Required. Select either Yes or No if the skin antiseptic agent was used as specified by age group.
Was skin preparation agent completely dry at time of first skin puncture?	Required. Check Yes if the skin prep agent was allowed to dry completely at the time of first skin puncture; otherwise select No. If not observed directly, ask inserter.

CLIP Toolkit Completed Insertions Tracking Form

Month: Year:

Date	Number of central lines inserted in prior calendar day		
	Surveillance ID:	Surveillance ID:	Surveillance ID:
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
Totals			

Instructions for completing the CLIP Toolkit Completed Insertions Tracking Form

The form should be completed at the same time every day in surveillance units using the CLIP Toolkit. On a given day, count the total number of patients in the ICU who had a central line inserted in the prior calendar day, including during night hours. To count these numbers, surveillance staff should first identify all patients who have a central line in the surveillance unit, and then discuss with clinical staff or examine medical records to identify whether the central line was placed on the prior calendar day by clinical staff in the surveillance unit. Central lines that were inserted in units other than the surveillance unit (e.g., in an operating theatre or casualty departments) should not be included.

At the beginning of each month, a new form should be prepared; the surveillance ID number for a unit using the CLIP Toolkit should be written in the column heading next to the term "Surveillance ID:".

At the end of the month, the numbers of all rows within a column should be summed to obtain the total number of new insertions performed in the surveillance unit. This total number should be written in the cell in the row titled "Totals" and in the column corresponding to the surveillance unit.

CLIP Toolkit Facility Level Data Report

Facility Name:
Surveillance ID 1:
Surveillance ID 2:
Surveillance ID 3:
Month:

Summary:

Table 1: Adherence %

Surveillance Units	N	Overall Adherence %		IPC Adherence %															
				Hand Hygiene		Mask		Gown		Gloves		Cap		Drape		Skin Prep		Skin Dry	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Facility																			
Surveillance Unit 1																			
Surveillance Unit 2																			
Surveillance Unit 3																			

Table 2: Femoral and Completed Insertions

Surveillance Units	N	Femoral Insertions		Completed	
		No.	%	No.	%
Facility					
Surveillance Unit 1					
Surveillance Unit 2					
Surveillance Unit 3					

Recommendations:

_____

_____

_____

_____

_____

_____

_____

_____

_____

Instructions for completing the CLIP Toolkit Facility Level Data Report

Complete the CLIP Facility Level Data Report using the Report tab of the CLIP database. See the table below for detailed instructions. This report should be shared with the Hospital Infection Control Committee monthly.

Data Field	Instructions
Facility Name	Required. Enter facility name.
Surveillance IDs	Required. For each surveillance unit, enter the surveillance ID.
Month	Required. Enter month observations were conducted.
Summary	Required. Provide narrative summary of data findings.
Table 1: Adherence %	Required. Copy and paste Table 1: Adherence % here.
Table 2: Femoral and Completed Insertions	Required. Copy and paste Table 2: Femoral and Completed Insertions here.
Recommendations	Required. Based on the data, provide recommendations to improve adherence rates.

11. Preventing Infections during Catheter Maintenance

Optimal care at the time of insertion, adherence to the central line bundle (as previously discussed), and prompt removal when a central line is no longer needed are vital components in CLABSI prevention. However, the risk for infection is present during the entire dwell time of the catheter. Intraluminal colonization becomes a significant risk factor for CLABSI with increasing time of placement. This risk is the reason for the current focus on CLABSI maintenance bundles.

Expanding the Insertion Bundle

Although the IHI states that the number of components in a preventive bundle should ideally be restricted to no more than five, to include practices routinely required for ongoing safe catheter maintenance, more than five key insertion practices are usually needed. The challenges of ensuring adherence to a post-insertion care bundle are significant. The IHI central line bundle is focused on placement, a single point in time. Post-insertion care involves every catheter access procedure, many clinicians and potentially several healthcare settings, and it is impossible to observe and monitor all behaviors. In general, post-insertion care focuses on:

- **Hand hygiene prior to all infusion-related procedures**
- **Aseptic technique with all catheter access procedures**
- **Proper changing of administration sets**
- **Changing needleless connectors according to manufacturer guidelines**
- **Attention to disinfection of needleless connectors prior to access**
- **Regular site care and dressing changes**
- **Daily review of catheter necessity, and prompt removal when it is no longer needed**

Central Line Maintenance Checklist									
Patient ID				Patient name					
Facility name		Surveillance unit			Date of admission to surveillance unit (dd/mm/yyyy) Shift timing (Morning/ Evening? Night)				
Section B. Daily checks									
Date (dd/mm/yyyy)	Central line day	Was the central line reviewed for necessity today?	Signature of day shift nurse	Was the dressing checked for soiling, dampening, and loosening today?	Signature of day shift nurse	Was the access port scrubbed with an antiseptic each time before use			
						During the day shift?	Signature of day shift nurse	During the night shift?	Signature of night shift nurse
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	
		□ Yes □ No		□ Yes □ No		□ Yes □ No		□ Yes □ No	

This form should only be completed for patients who have a central venous catheter (hereafter, central line) in the surveillance unit.

Section A should be completed by the nurse providing care for the patient on the first day that a patient with a central line enters the surveillance unit, or on the first day that a central line is placed in a patient already in the surveillance unit.

Section B should be completed on a daily basis by the nurse providing care for the patient.

Date corresponds to the date of care of the patient with the central line.

Central line day refers to the number of days the patient has had a central line, with the day of insertion equal to day 1.

Was the central line reviewed for necessity?

The shift nurse is responsible for communicating with the treating physician whether the central line was reviewed for necessity. If the treating physician confirms that the central line was reviewed for necessity for that day , then the nurse should mark "Yes" in the box corresponding to the date of care under the column of the question. Otherwise, the nurse should mark "No". The nurse should then sign in the box next to the response for the appropriate shift.

Was the dressing checked for soiling, dampening, and loosening?

The shift nurse is responsible for checking whether the dressing for the central line is soiled, damped, or loosened. After the nurse has checked for soiling, dampening, and loosening, the box corresponding to date of care under the column of the question should be marked "Yes". If the dressing was not checked, the nurse should mark "No". The nurse should then sign in the box next to the response for the appropriate shift.

Was the access port scrubbed with an antiseptic each time

During the day shift

At the end of the day shift, the day shift nurse should mark whether an appropriate antiseptic was used to scrub the access port of the central line each time before use during the day shift. If an antiseptic was used every time the port was accessed during the day shift, then the day shift nurse should mark "Yes" for in the box corresponding to the date at the end of the shift. If the port was not scrubbed with an antiseptic at each use, then the day shift nurse should mark "No". The nurse should then sign next to the response for the appropriate shift.

During the night shift

At the end of the night shift, the night shift nurse should mark whether an appropriate antiseptic was used to scrub the access port of the central line each time before use during the night shift. If an antiseptic was used every time the port was accessed during the night shift, then the night shift nurse should mark "Yes" for in the box corresponding to the date at the end of the shift. If the port was not scrubbed with an antiseptic at each use, then the night shift nurse should mark "No". The nurse should then sign next to the response for the appropriate shift.

Additional copies of this form should be used if a patient has more central lines than the number of rows available on the form. In the event of central line removal, the use of this form should be discontinued unless a new central line is placed the same day or one calendar day after removal.The form should be kept with the IPC incharge of the unit or in Patient's file (based on the hospital's policy)

12. Scrub the Hub!

It is important to focus on the individual needleless connectors and be aware of the specific manufacturer recommendations to facilitate appropriate use. Failure to disinfect the needleless connector before accessing has been an important problem and area of concern. The catheter hub and needleless connector are known sources of microbial contamination and present a source for development of a bloodstream infection. Historically the method for disinfecting the access port involved a "scrub the hub" process whereby alcohol, iodophors, chlorhexidine, alcohol/chlorhexidine combinations could be used. More recently, the focus has shifted to use of disinfection caps that can be placed on the access port to maintain a level of disinfection. Various disinfection combinations are currently available, including alcohol and alcohol/chlorhexidine combinations. These plastic caps are placed on the access point in between intermittent infusions, thus minimizing contamination opportunities of the access point. The recent Society for Healthcare Epidemiology of America (SHEA) guidelines recommend use of disinfection caps as a special approach in locations/populations with unacceptably high CLABSI rates despite implementation of basic practice recommendations. In terms of how long to scrub the needleless connector, a 5-second scrub is adequate with split septum type of needleless connectors. There is not a well-accepted guideline for other types of needleless connectors, but at least 15 seconds is common in some studies.

Which hubs have to be scrubbed? Every port on the system, injection ports into bags or bottles, injection ports on administration sets, needless connectors, and the hub of a catheter itself are potential portal of entry for infection. Closed catheter access systems are preferred as they are associated with fewer central line–associated bloodstream infections (CLABSIs) than open systems.

Stopcocks and injection ports should be capped when not being used.

SCRUB THE HUB YOU ARE ACCESSING EVERY TIME YOU ACCESS IT!

If you continue to have a high rate of infections, consider using alcohol-impregnated port protectors, scrubbing devices, and needleless neutral displacement connectors in addition to scrubbing the hub.

How do you scrub the hub? Adequately scrubbing the hub depends on the agent you use, appropriate contact and drying time, and—most important—friction.

To Scrub the Hub:

1. **Perform hand hygiene.**
2. **Don clean or sterile gloves.**
3. **Use a scrubbing device with an alcohol product such as chlorhexidine with alcohol or 70%**
4. **alcohol to disinfect catheter hub and stopcocks. If you are using a pad, make sure you don't contaminate it before use and use only on one hub. Prep pads should NEVER be reused.**
5. **Rub for 10 to 15 seconds (unless directed otherwise by the manufacturer's instructions), generating friction by scrubbing in a twisting motion as if you were juicing an orange. Make sure you scrub the top of the hub well, not just the sides.**
6. **Allow the hub to dry. Prevent it from touching anything while drying.**
7. **Access the stopcock or injection port only with sterile devices.**

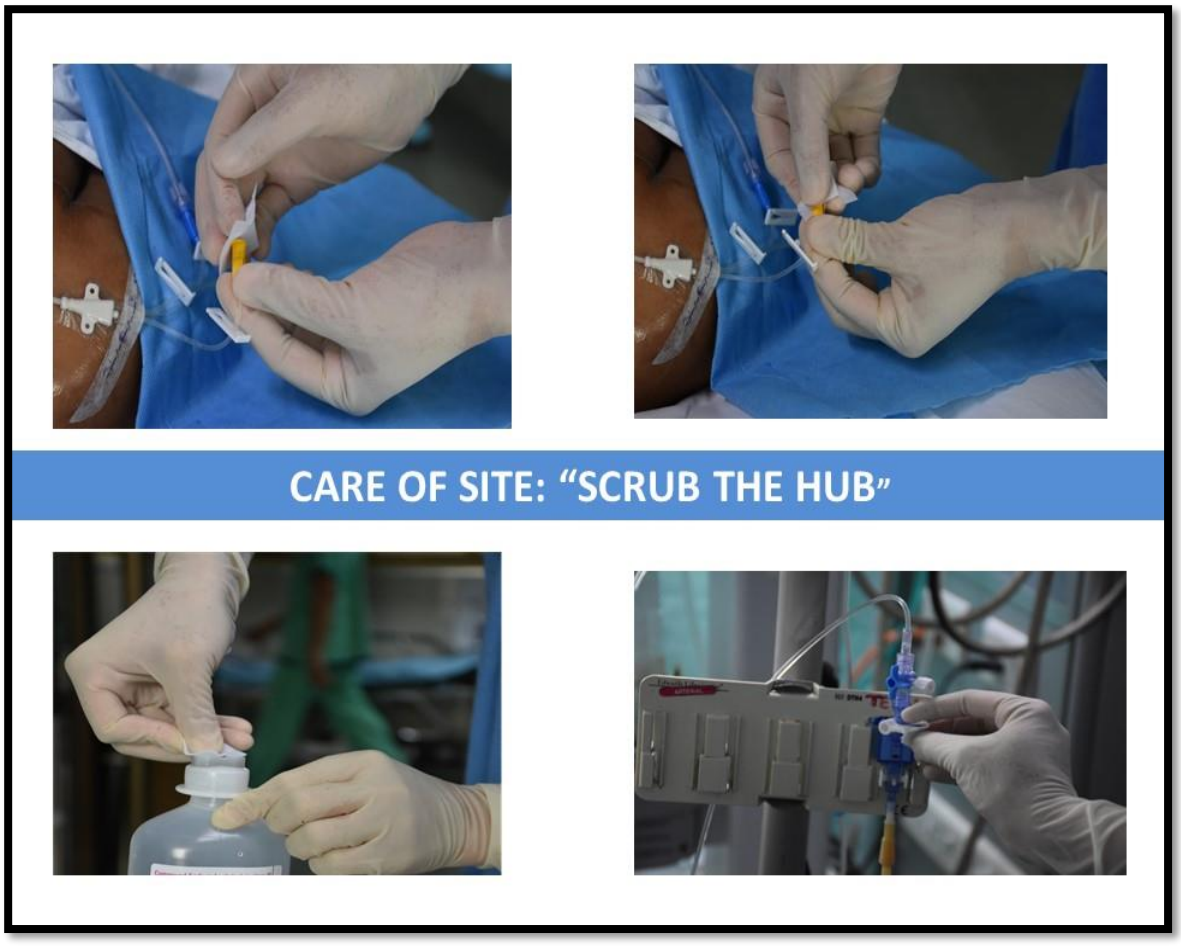


Figure 15 : Method of scrubbing the hub

13. Preventing CLABSI in the Pediatric Population

Intravenous devices used in clinical treatment modalities are a known risk factor for CLABSI in both adult and pediatric populations. Children and premature infants are at risk for CLABSI due to intrinsic risks, such as gestational age, birth weight, and immune system immaturity. Extrinsic risks include invasive and frequent vascular access for infusion and blood sampling, patient positioning and handling, and variation in line technique due to prolonged healthcare exposure. The critical status, length of stay, type of device, and age of these children may lead to multiple transfusions, cardiopulmonary bypass, delayed sternal closure, extracorporeal membrane oxygenation, altered tissue perfusion, and hypoxia, subsequently increasing the associative risks for infection. Children with hematologic and oncologic disease processes may be at risk for CLABSI as a result of profound neutropenia, prolonged total parenteral nutrition, relatedness of transplant, and impaired mucosal integrity. In response to these observations, the CDC modified the current CLABSI definitions to include categorization for mucosal barrier injury laboratory confirmed bloodstream infection in eligible patient populations.

In the context of CLABSI prevention, IPs should help reinforce that pediatric care is not the same when compared to other age groups. Securing a central line in a neonate is different than in a child or teenager. With a neonate, one might consider proximity of all medical devices (such as gastrostomy tubes) and securing the line away from opportunities for transient contamination (such as secretions from endotracheal tubes or being tucked into a diaper).

Example of a Central Catheter Maintenance Form Used in Pediatrics

Central Line Maintenance Information

Date:	Mon:	Tues:	Wed:	Thurs:	Fri:	Sat:	Sun:
Was patient on enteral feeding? Volume:	□ <120ml/ kg/day □ ≥120ml/ kg/day/ □ None	□ <120ml/ kg/day □ ≥120ml/ kg/day/ □ None	□ <120ml/ kg/day □ ≥120ml/ kg/day/ □ None	□ <120ml/kg/ day □ ≥120ml/kg/ day/ □ None	□ <120ml/kg/ day □ ≥120ml/kg/ day/ □ None	□ <120ml/kg/ day □ ≥120ml/kg/ day/ □ None	□ <120ml/kg/ day □ ≥120ml/kg/ day/ □ None
If yes, during multidisciplinary rounds today, did we decide the baby still needs this line?	□ Yes □ No □ Don't Know	□ Yes □ No □ Don't Know	□ Yes □ No □ Don't Know	□ Yes □ No □ Don't Know	□ Yes □ No □ Don't Know	□ Yes □ No □ Don't Know	□ Yes □ No □ Don't Know
Type of Catheter:	□ UAC □ UVC □ PICC □Broviac□Other						

Shift :	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Was catheter accessed for any reason during your shift?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If Yes, did staff adhere to aseptic techniques?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, did perform hand hygiene before and after gloving?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, Was hub/ connector cleaned for at least 15 seconds with alcohol?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, was solution allowed to dry?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Was Infusion tubing changed during your shift?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If Yes, did staff adhere to aseptic techniques?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No

It is important to secure the line away from opportunities that might allow an infant to manipulate the catheter or place the line in his or her mouth. Especially when feeling better, children with central lines may interact with siblings and pets and may engage in rough play that could potentially dislodge the central line.

Considerations for Use of Needleless Connectors in Pediatrics

Connector profile – A larger profile cap may result in unintended issues such as a breakdown in skin integrity due to pressure from the connector or inadvertent dislodging of an intravenous line due to the weight and pull of the larger cap. Also, a larger profile cap may be difficult to secure on a small baby or neonate.

Surface features – Irregular, raised, or concave surfaces may affect the ability to adequately disinfect the surface. Gaps between the surface and the internal parts of the connector may pose difficulty in disinfecting

Flush volume – A smaller flush volume is best, especially for patients that are fluid restricted or are unable to manage a bolus of fluid (e.g., very low birth weight babies, small infants, and neonates). Additionally, pediatric patients may require small volume delivery of medications, thereby making a larger volume connector problematic.

Flushing performance – Connectors that maintain blood after being flushed present a risk for infection. Connectors should be able to be cleared of blood with the minimal amount of fluid.

High-pressure compatibility – On occasion, patients may require administration of fluids at a higher pressure (e.g., rapid infusers in the emergency department).

CLABSI in the NICU

Preventing and managing CLABSIs in the neonatal intensive care unit (NICU) is challenging because of the need for invasive devices and the extreme vulnerability of this population. The risk of infection due to a central line varies based on a number of factors, including birth weight, gestational age, type of line, and life of the line.

Development of programs to prevent and manage CLABSI in the neonatal population should be done with consideration of gestational age of the patient. Gestational age may indicate the patient's risk of infection and the skin's ability to act as a barrier against infection.

Depending on the gestational age of the infant, he or she may be at risk for burns and/or scalding related to use of certain antiseptics such as chlorhexidine gluconate (CHG), or systemic absorption of other antiseptics, such as providence iodine (PI).

Additional studies are needed to determine best practices related to skin antiseptics of the premature infant.

The following may be considered for determining the appropriate skin antiseptic for the premature infant:

Product efficacy in the neonatal population

Potential for system toxicity via skin absorption

Potential for skin irritation, chemical burns, or erosive contact dermatitis related to product use

15. References

1. Mermel LA. Prevention of intravascular catheter-related infections. Ann Intern Med 2000; 132:391–402.
2. Grady N. Preventing Intravascular Catheter Related Infections d CID 2011:52 (1 May)
3. Infusion Nurses Society. Infusion nursing standards of practice. *J InfusNurs*2011; 34(1S),S102.
4. Stevens V, et al. Inpatient costs, mortality and 30-day re-admission in patients with central line-associated bloodstream infections. *ClinMicrobiol Infect* 2014; v20, issue 5; 318-324.
5. Umscheid CA, Mitchell MD, Doshi, TA, et al. Estimating the proportion of healthcare-associated infections that are reasonably preventable and the associated mortality and costs. *Infect Control Hosp Epidemiol*2011; Feb;32(2):101-114.
6. Resar R, et al. *Using Care Bundles to Improve Health Care Quality*. IHI Innovation Series white paper. Cambridge, Massachusetts: Institute for Healthcare Improvement, 2012. Available at http://www.ihi.org/knowledge/Pages/ IHIWhitePapers/UsingCareBundles.aspx.
7. Worth, LJ, McLaws, ML.Is it possible to achieve a target of zero central line associated bloodstream infections? *CurrOpin Infect Dis* 2012; 25(6):650-657.
8. Centers for Disease Control and Prevention (CDC). Reduction in central line-associated bloodstream infections among patients in intensive care units—Pennsylvania, April 2001-March 2005. *MMWR* 2005; 54(40):1013-1016.
9. Pronovost P, Goeschel C, Colantuoni E, et al. Sustaining reductions in catheter related bloodstream infections in Michigan intensive care units: Observational study. *BMJ* 2010; Feb 4:340-309.
10. Institute for Healthcare Improvement (IHI). IHI global trigger tool for measuring adverse events. Available at http://www.ihi.org/resources/Pages/Tools/ IHIGlobalTriggerToolforMeasuringAEs.aspx.
11. American Nurses Association. Nursing sensitive indicators. Available at http://www.nursingworld.org/ MainMenuCategories/ThePracticeofProfessionalNursing/ PatientSafetyQuality/Research-Measurement/ The-National-Database/Nursing-Sensitive-Indicators_1.
12. Press Ganey Acquires National Database of Nursing Quality Indicators (NDNQI®). Available at http://www.prnewswire.com/news-releases/press-ganey-acquires-national-database-of-nursing-quality-indicators-ndnqi-262538811.html.
13. Updated Guidelines for Evaluating Public Health Surveillance Systems — Recommendations from the Guidelines Working Group, 2001. Available at http://www.cdc.gov/mmwr/preview/ mmwrhtml/rr5013a1.htm.
14. O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of intravascular catheter-related infections. *Am J Infect Control* 2011; 39:S1-34
15. Lee TB, Montgomery OG, Marx J, et al. Recommended practices for surveillance. *Am J Infect Control* 2007; 35:427-40.
16. Pien BC, Sundaram P, Raoof N, et al. The clinical and prognostic importance of positive blood cultures in adults. *Am J Med* 2010; Sep;123(9):819-28.
17. Baron EJ, ed. *Cumitech 1C: Blood Cultures IV*. Washington, DC: American Society for Microbiology (ASM), 2005.
18. Mermel LA, Allon M, Bouza E, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 update by the Infectious Diseases Society of America. *Clin Infect Dis* 2009; 49:1-45.
19. Infusion Nurses Society. Infusion nursing standards of practice. *J InfusNurs*2011; 34:S1-S109.
20. Lin MY, Hota B, Khan YM, Woeltje KF, et al. Quality of traditional surveillance for public reporting of nosocomial bloodstream infection rates. *JAMA* 2010; 304:2035-41.
21. Mayer J, Greene T, Howell J, et al. Agreement in classifying bloodstream infections among multiple reviewers conducting surveillance. *Clin Infect Dis* 2012; Aug;55(3):364-70
22. Fridkin SK, Olmsted RN. Meaningful measure of performance: A foundation built on valid, reproducible findings from surveillance of health care-associated infections. *Am J Infect Control* 2011; Mar;39(2):87-90.
23. Tokars JI, Richards C, Andrus M, et al. The changing face of surveillance for health care-associated infections. *Clin Infect Dis* 2004; 39:1347-52.

24. Goeschel CA, Pronovost PJ. "Harnessing the Potential of Health Care Collaboratives: Lessons from the Keystone ICU Project" In: *Advances in Patient Safety: New Directions and Alternative Approaches*, (Vol. 2: Culture and Redesign), Henriksen K, Battles JB, Keyes MA, Grady ML, eds. Rockville, MD: Agency for Healthcare Research and Quality, 2008: 1-2.
25. Digiorgio MJ, Fatica C, Oden M, et al. Development of a modified surveillance definition of central line-associated bloodstream infections for patients with hematologic malignancies. *Infect Control Hosp Epidemiol*2012; Sep;33(9):865-868.
26. Wright MO, Hebden JN, Allen-Bridson K, et al. American Journal of Infection Control and National Healthcare Safety Network data quality collaboration: A supplement of new case studies. *Am J Infect Control* 2012; 40:S32-40.
27. Schulman J, et al. Statewide NICU central line-associated bloodstream infection rates decline after bundles and checklists. *Pediatrics* 2011; Mar;127(3):436-44.
28. Berenholtz SM, Lubomski LH, Weeks K, et al. Eliminating central line-associated bloodstream infections: A national patient safety imperative. *Infect Control Hosp Epidemiol*2014; Jan;35(1):56-62
29. Agency for Healthcare Research and Quality (AHRQ). Making Health Care Safer II: An Updated Critical Analysis of the Evidence for Patient Safety Practices – Executive report. 2013. Available at http://www.ahrq.gov/research/findings/ evidence-based-reports/ptsafetysum.html.
30. National Healthcare Safety Network (NHSN). Surveillance for Central Line Insertion Practices (CLIP) Adherence. Available at http://www.cdc.gov/nhsn/acute-care-hospital/clip/index.html.
31. Society for Healthcare Epidemiology of America (SHEA)/ Infectious Diseases Society of America (IDSA). Strategies to prevent central line-associated bloodstream infections in acute care hospitals: 2014 update. Available at http://www.jstor.org/ stable/10.1086/676533.
32. US Food and Drug Administration (FDA). 2% Chlorhexidine Gluconate (CHG) Cloth. May 2012. Available at http://www.fda.gov/Safety/MedWatch/SafetyInformation/Safety-RelatedDrugLabelingChanges/ucm307387.htm.
33. Segreti J, Garcia-Houchins S, Gorski L, et al. Consensus conference on prevention of central line-associated bloodstream infections: 2009. *J InfusNurs*2011; Mar-Apr;34(2):126-133.
34. Royer T. Implementing a better bundle to achieve and sustain a zero central line-associated bloodstream infection rate. *J InfusNurs*2010; Nov-Dec;33(6):398-406.
35. O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of intravascular catheter-related infections. *Am J Infect Control* 2011; 39:S1-34.
36. Hornsby S, Matter K, Beets B. Cost losses associated with the "PICC, stick, and run team" concept. *J InfusNurs*2005; Jan-Feb;28(1):45-53.
37. Markovich MB. The expanding role of the infusion nurse in radiographic interpretation for peripherally inserted central catheter tip placement. *J InfusNurs*2008; Mar-Apr;31(2):96-103.
38. Hind D, Calvert N, McWilliams R, et al. Ultrasonic locating devices for central venous cannulation: Meta-analysis. *BMJ* 2003; Aug 16;327-361.
39. Froehlich CD, Rigby MR, Rosenberg ES, et al. Ultrasound-guided central venous catheter placement decreases complications and decreases placement attempts compared with the landmark technique in patients in a pediatric intensive care unit. *Crit Care Med* 2009; Mar;37(3):1090-6.
40. Ryder M., et al. Differences in bacterial transfer and fluid path colonization through needle free connector-catheter systems in vitro. Paper presented at Society for Healthcare Epidemiology of America meeting, Dallas, Apr 29, 2011.
41. Sweet MA, et al. Impact of alcohol-impregnated port protectors and needleless neutral pressure connectors on central line–associated bloodstream infections and contamination of blood cultures in an inpatient oncology unit. *Am J Infect Control*. 2012 Dec;40(10):931–934. doi: 10.1016/j.ajic.2012.01.025. Epub 2012 May 9.