Beyond the Bundle: Reducing the Risk of Central Line-Associated Bloodstream Infections

ABSTRACT

Central venous catheterization is one of the most widely used invasive procedures, and it significantly increases the risk for infection. Sustained reduction of central line-associated bloodstream infection (CLABSI) remains elusive in many institutions despite increased awareness of evidence-based preventive strategies, publication of successful hospital CLABSI elimination programs, and elimination of reimbursement for the cost of treating CLABSIs. A March 2009 Centers for Disease Control and Prevention report estimates the cost of one CLABSI in 2007 U.S. dollars to be $29,156, which totals $2.68 billion in excess costs annually. A study by Klevens et al. found that of the 98,987 patient deaths caused by or associated with healthcare-associated infections in 2002, 31% of those cases were attributed to bloodstream infections. Pennsylvania hospitals answer questions in each CLABSI report submitted to the National Healthcare Safety Network indicating compliance with three evidence-based practices including use of maximal sterile barriers, chlorhexidine site preparation, and documentation of review of daily necessity for continuation of the central line. The Pennsylvania Patient Safety Authority's analysis of CLABSI event reports from July 2008 through March 2009 concludes that while Pennsylvania's CLABSI and central line utilization rates are significantly better than the national average, hospitals were unable to document compliance with evidence-based best practices for CLABSI prevention in 38% of events reported. Hospitals with the lowest CLABSI rates reported twice the use of all three practices than hospitals with the highest rates of infection. The key to achieving sustainable, actionable CLABSI reduction is to combine adaptive cultural changes with evidence-based practices and a renewed focus from hospital leaders and clinicians on a culture of safety. (Pa Patient Saf Advis 2010 Mar;7[Suppl 1]:1-9.)

Introduction

Central venous catheters (CVC) are vital in modern-day medical practice, particularly in the intensive care unit (ICU); however, their use puts patients at risk for central line-associated bloodstream infection (CLABSI) complications. These deadly and often preventable infections increase the risk of morbidity and mortality and prolong hospital stays.[1] Practical risk reduction strategies enable consistent application of evidence-based recommendations for central line insertion and maintenance. Healthcare workers must be educated and engaged in a culture of safety to achieve consistent application of these recommendations.

As described by the Institute for Healthcare Improvement (IHI), the central line bundle is a group of evidence-based interventions for patients with CVCs that individually improve care and, when implemented together, result in substantially better outcomes. The science supporting each bundle component has sufficiently established each to be the standard of care. The five key components of the IHI central line bundle are as follows: hand hygiene, maximal sterile barriers, chlorhexidine skin antisepsis, optimal catheter site selection (with subclavian vein as the preferred site for nontunneled catheters), and daily review of line necessity with prompt removal of unnecessary lines.[2]

The Association for Professionals in Infection Control and Epidemiology (APIC) promotes a culture of zero tolerance for healthcare-associated infections (HAI) and unsafe practices associated with them. APIC Vision 2012, APIC's strategic plan, includes the expectation that healthcare workers will consistently apply infection prevention and control measures and will have access to resources and administrative support.[3]

U.S. Department of Health and Human Services Secretary Kathleen Sebelius has also called on hospitals across America to commit to reducing CLABSIs in ICUs by 75% over the next three years.[4]

Sustained reduction of CLABSIs remains elusive in many institutions despite increased awareness of evidence-based preventive strategies, publication of successful hospital CLABSI elimination programs, and elimination of reimbursement for the cost of treating CLABSIs. The key to achieving sustainable, actionable CLABSI reduction is to combine adaptive cultural changes with evidence-based practices and a renewed focus from hospital leaders and clinicians.

Background

CLABSI is a serious complication of intravascular therapy used to deliver medication, blood, or nutrition. Central venous catheterization is a widely used invasive procedure and significantly increases the risk for bloodstream infection.[1] That risk increases for patients whose catheters are inserted during non-sterile emergent situations and for patients who are discharged with lines in place for long-term intravenous therapies. The use of central lines is becoming more common in non-ICU patients.[5]

Once in contact with a CVC, bacteria rapidly secrete an adhesive-like substance, causing the organisms to stick to the catheter sheath. The bacteria then produce a protective biofilm. Antibiotics and white blood cells cannot penetrate the biofilm to kill the bacteria. In a 2002 review of biofilm resistance to antimicrobial agents, Donlan et al. found that the age of the biofilm may affect its susceptibility to antibiotics and that 10-day-old biofilm are significantly more resistant than 2-day-old biofilm.[6]

Catheter flushing, infusion, and movement can cause detachment of clumps or fragments of the biofilm, which may contain thousands of bacterial cells. These bacteria then float into the patient's bloodstream and lead to systemic infections, often with endotoxin release. Usually, the only means of treatment requires removal of the biofilm-encrusted device.[7]

Socioeconomic Burden

Bloodstream infections associated with an intravascular device are the most life-threatening type of infection related to invasive medical devices.[7] CLABSIs require additional treatments that impose significant economic consequences. The downstream effects of these infections include extended illness, loss of wages, and the intangible costs related to a diminished quality of life. A March 2009 Centers for Disease Control and Prevention (CDC) report estimates the cost of one CLABSI in 2007 U.S. dollars to be $29,156, which totals $2.68 billion in excess costs annually.[8] A study by Klevens et al. found that 98,987 patient deaths were caused by or associated with HAIs in 2002, and 31% of those HAIs were attributed to bloodstream infections.[9] In an evidence-based practice advisory study of reasonably preventable infections using a 2002 estimate, Umscheid et al. calculated that a reduction in the risk of septicemia with implementation of recommended infection control measures ranges from 18% to 82%, equaling 5,520 to 25,145 preventable deaths a year.[10]

CLABSI Data Snapshot

The Health Care-Associated Infection Prevention and Control Act, Act 52 of 2007, requires healthcare facilities in Pennsylvania to report HAI data to the Pennsylvania Department of Health, the Pennsylvania Health Care Cost Containment Council, and the Pennsylvania Patient Safety Authority through CDC's National Healthcare Safety Network (NHSN).[11] The NHSN CLABSI event reports were customized for Pennsylvania hospitals to include reporting of compliance with nationally recognized, evidence-based best practices. Facilities answer questions in each CLABSI report submitted to NHSN indicating compliance with three evidence-based practices, including use of maximal sterile barriers during insertion, chlorhexidine site preparation, and documentation of review of daily necessity for continuation of the central line. These practices for central line insertion have been recommended since 2002 by CDC,[1] IHI,[2] and, more recently, the Society for Healthcare Epidemiology of America (SHEA).[12]

The Authority's analysis of CLABSI events from Pennsylvania hospitals (all unit types), as reported to NHSN from July 2008 through March 2009, calculated average CLABSI rates of 1.8/1,000 central line days for critical care areas and 1.1 for ward locations, which is significantly better than the national averages of 2.0/1,000 central line days for critical care areas and 1.4 for ward locations ($p < 0.01$; *z*-test for two proportions). Additionally the Authority's analysis shows that the central line utilization rates of 0.45 in critical care and 0.11 in ward locations in Pennsylvania are significantly better than the national averages of 0.48 in critical care and 0.16 in ward locations ($p < 0.01$; *z*-test for two proportions).[13] (See Table 1.)

Analysis of Pennsylvania NHSN CLABSI events found that compliance with the evidence-based best practices averaged 55.8% for the 1,916 CLABSI reports. However, 38% of the CLABSI reports documented unknown compliance with these basic best practices, and 4.4% of the remaining responses indicated that the best practices were not used. The best practice questions were not answered in 1.5% of the reports. (See Table 2.)

Excluding hospitals that did not know if the best practices were used, stated that they were not applicable, or left the answer blank, the hospitals in the quartile with the lowest CLABSI rates had significantly higher rates of compliance than hospitals in the quartile with the highest CLABSI rates for the use of maximum sterile barriers (186/187 versus 482/503; $p < 0.05$, chi-square test), chlorhexidine insertion protocols (193/196 versus 457/503; $p < 0.001$, chi-square test), and daily evaluation and documentation of central line necessity (186/201 versus 373/510; $p < 0.001$, chi-square test). (See Table 2.)

Of the 160 hospitals that reported CLABSIs, 14 (35%) of the hospitals in the quartile with the lowest rates consistently used all three best practices, compared to 7 (17.5%) of the hospitals in the quartile with the highest rates (although the difference was not statistically significant). (See Table 3.)

Authority analysis of the hospital reports concludes that the high performing hospitals had an average CLABSI rate of 0.98/1,000 central line days and 18.5% of the statewide total of CLABSI. Low performing hospitals had an average CLABSI rate of 3.3/1,000 central line days and 45.6% of the total CLABSI. (See Tables 2 and 3.)

This analysis highlights the finding that more consistent use of maximal sterile barriers and chlorhexidine insertion protocols had a positive impact on Pennsylvania CLABSI rates. However, this analysis also demonstrates that documentation of daily necessity and methods of accurately measuring compliance with best practices remains a struggle in some organizations. Programs to target zero CLABSI need to be adopted to help avoid complacency and to give clinicians a tangible goal to strive toward.

In early 2010, the Pennsylvania Department of Health released its report on HAIs in Pennsylvania hospitals, for the second half of 2008, which includes CLABSI

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Table 1. Comparison of National and Pennsylvania Central Line-Associated Bloodstream Infection Rates*

	NATIONAL HEALTHCARE SAFETY NETWORK (NHSN), 2006 THROUGH 2008†,1					PENNSYLVANIA, JULY 2008 THROUGH MARCH 2009‡				
	Patient Days	No. of CLABSI	Central Line Days	CLABSI Rate§	Central Line Utilization€	Patient Days	No. of CLABSI	Central Line Days	CLABSI Rate§	Central Line Utilization€
Critical Care Units										
Burn	126,826	390	70,932	5.5	0.56	8,546	17	4,301	4.0	0.50
Medical	1,699,768	2,097	911,476	2.3	0.54	104,777	90	57,174	1.6	0.55
Medical cardiac	1,096,749	876	436,409	2.0	0.40	81,743	43	27,417	1.6	0.34
Medical/surgical	5,073,058	4,053	244,1719	1.7	0.48	330,898	250	149,840	1.7	0.45
Neonatal intensive care unit level II and III	1,893,787	870	349,263	2.5	0.18	190,060	120	45,196	2.7	0.24
Neurologic	100,840	61	45,153	1.4	0.45	14,308	10	6,915	1.4	0.48
Neurosurgical	362,881	396	160,879	2.5	0.44	29,283	20	13,694	1.5	0.47
Pediatric cardiothoracic	95,130	195	58,626	3.3	0.62	14,696	28	6,982	4.0	0.48
Pediatric medical	43,797	23	17,321	1.3	0.40	1,587	1	525	1.9	0.33
Pediatric medical/ surgical	655,402	929	314,306	3.0	0.48	23,511	50	13,997	3.6	0.60
Respiratory	29,520	29	17,223	1.7	0.58	6,380	11	3,462	3.2	0.54
Surgical	1,230,430	1,683	729,989	2.3	0.59	54,123	57	36,301	1.6	0.67
Surgical cardiothoracic	893,084	879	632,769	1.4	0.71	76,362	54	50,541	1.1	0.66
Trauma	354,494	814	224,864	3.6	0.63	38,366	41	25,927	1.6	0.68
Totals	**20,428,592**	**19,445**	**9,764,124**	**2.0**	**0.48**	**974,640**	**792**	**442,272**	**1.8**	**0.45**
Inpatient Wards										
Adult step down	793,149	299	141,374	2.1	0.18	438,472	80	61,657	1.3	0.14
Behavioral health/ psychiatric	83,545	0	1,803	0.0	0.02	519,564	0	1,604	0.0	0.00
Genitourinary	57,237	22	16,902	1.3	0.30	15,861	1	3,071	0.3	0.19
Gerontology	18,567	4	2,674	1.5	0.14	9,530	3	1,326	2.3	0.14
Gynecology	60,466	6	5,694	1.1	0.09	17,735	1	1,857	0.5	0.10
Labor and delivery/ recovery	25,892	0	810	0.0	0.03	112,335	0	357	0.0	0.00
Medical	1,408,507	422	278,221	1.5	0.20	766,481	157	140,819	1.1	0.18
Medical/surgical	3,839,045	733	618,196	1.2	0.16	2,211,320	327	280,162	1.2	0.13
Neurologic	69,343	8	10,723	0.7	0.15	25,384	2	2,560	0.8	0.10
Neurosurgical	83,780	12	13,866	0.9	0.17	41,521	3	6,488	0.5	0.16
Nursery I & II	9,197	2	1,516	1.3	0.16	123,390	1	335	3.0	0.00
Orthopedic	343,273	32	40,425	0.8	0.12	199,385	9	15,920	0.6	0.08
Pediatric medical	59,826	18	10,232	1.8	0.17	48,499	17	8,170	2.1	0.17
Pediatric medical/ surgical	165,571	102	32,581	3.1	0.20	89,891	20	9,129	2.2	0.10
Postpartum	67,780	0	943	0.0	0.01	189,550	0	579	0.0	0.00
Rehabilitation	570,671	39	47,052	0.8	0.08	470,420	21	31,779	0.7	0.07
Surgical	664,399	189	132,336	1.4	0.20	361,418	49	62,548	0.8	0.17
Vascular surgery	50,079	13	11,345	1.1	0.23	14,627	0	2,055	0.0	0.14
Totals	**8,370,327**	**1,901**	**1,366,693**	**1.4**	**0.16**	**5,655,383**	**691**	**630,416**	**1.1**	**0.11**
Long-Term Care Units	63,417	6	6,030	1.0	0.10	5,022	1	795	1.3	0.16

* The Pennsylvania care locations included in rate calculation were limited to those locations also published in the NHSN data summary.

† NHSN data summary for 2006 through 2008.

‡ Authority analysis of Pennsylvania CLABSI reports to NHSN from July 2008 through March 2009.

§ CLABSI rate: number of CLABSIs / number of line days x 1,000.

€ Device utilization rate: number of line days / number patient days.

Note

1. Edwards JR, Peterson KD, Andrus ML. National Healthcare Safety Network (NHSN) report, data summary for 2006 through 2008. *Am J Infect Control* 2009 Dec;37(10):783-805.

Table 2. Pennsylvania Patient Safety Authority Analysis of CLABSI Prevention Best Practice Compliance, by Event*

CENTRAL LINE-ASSOCIATED BLOODSTREAM INFECTION [CLABSI] BEST PRACTICES	USED	NOT USED	USE UNKNOWN	NOT APPLICABLE	NO ANSWER
Statewide (N = 1,916; CLABSI Rate 1.46 / 1,000 Central Venous Catheter [CVC] Days)					
Maximal sterile barriers used during line insertion	1,098	26	761	2	29
Chlorhexidine skin asepsis used during line insertion	1,068	59	746	14	29
Line necessity evaluated daily and documented	1,044	167	677	1	27
Lowest Quartile Rates (n = 354 CLABSI; CLABSI Rate 0.98 / 1,000 CVC Days)					
Maximal sterile barriers used during line insertion	186	1	157	0	10
Chlorhexidine skin asepsis used during line insertion	193	3	144	4	10
Line necessity evaluated daily and documented	186	15	143	0	10
Highest Quartile Rates (n = 874 CLABSI; CLABSI Rate 3.3 / 1,000 CVC Days)					
Maximal sterile barriers used during line insertion	482	21	365	0	8
Chlorhexidine skin asepsis used during line insertion	457	46	364	1	8
Line necessity evaluated daily and documented	373	137	358	0	8

* Authority analysis of Pennsylvania CLABSI reports to the National Healthcare Safety Network from July 2008 through March 2009.

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outcomes. See the box "2008 Report: Healthcare-Associated Infections in Pennsylvania Hospitals."

Barriers to Progress

Gurses et al. report that interventions to overcome barriers are often implemented without an investigation into the actual reasons for failure to standardize care processes.[14] Translating evidence into practice requires a systematic approach to identify, prioritize, and remove barriers. Gurses' program to eliminate barriers to compliance recommends assembly of a team of frontline workers and quality improvement staff to collect data and identify barriers. This can be accomplished by observing staff during central line insertion and maintenance processes, simulating the process while attempting to comply with the protocols, and interviewing healthcare workers about issues with process compliance. Contributing factors that prevent consistent and appropriate application of evidence-based practices include the following:

Provider factors. These include knowledge of the elements of the guideline, attitude toward the guideline, perceived compliance with the guideline, current practice habits, and the influence of unit culture on compliance.

Guideline factors. These include applicability of the guideline to the patients on the unit, ease of compliance, and strength of scientific evidence.

System factors. These include barriers to clear process task responsibility, availability of resources and supplies, appropriate use of supplies, and use of decision aids such as checklists and standing orders. System barriers also include how the unit's physical structure affects compliance, as well as adequacy of staffing and policies, administrative support, performance monitoring, and feedback.

Data derived from the barrier identification process can then be summarized and prioritized, and an action plan can be developed for each targeted barrier. Practical tools to enable clinicians and leadership to identify and analyze and address barriers in the care setting can be found in the October 2009 *Joint Commission Journal on Quality and Patient Safety*.[14]

CLABSI Risk Reduction Strategies

Infection Control—Leadership and Accountability

The Joint Commission National Patient Safety Goals (NPSGs) outline specific elements of performance for implementation of evidence-based practices to prevent CLABSI. By April 2009, hospital leadership was required to assign responsibility for oversight and coordination of the implementation of all the elements of NPSG.07.0401 and to ensure that a work plan is in place with assigned accountabilities and timeline for full implementation by January 1, 2010.[15]

The Comprehensive Unit-Based Safety Program (CUSP) developed by the Johns Hopkins Quality and Safety Research Group describes the senior executive's role as a partnership to bridge the gap between

Table 3. Pennsylvania Patient Safety Authority Analysis of CLABSI Prevention Best Practice Compliance, By Hospital*

	STATEWIDE	HIGH PERFORMERS	LOW PERFORMERS
Number of hospitals reporting central line-associated bloodstream infections (CLABSI)	160	40	40
Compliance with all three best practices	32	14	7
Percentage of compliance	20%	35%	17.5%
CLABSI rate / 1,000 line days	1.46	0.98	3.30

* Authority analysis of Pennsylvania CLABSI reports to the National Healthcare Safety Network from July 2008 through March 2009.

senior management and frontline providers by conducting safety rounds. The executive meets with providers on the unit while discussing safety issues and helps remove barriers to implementing improvement efforts. The executive's role is also to stimulate further discussions about safety, help prioritize safety concerns, suggest solutions to these concerns, and help set goals for the unit. Executives may not be aware that system defects exist in their hospital, and tremendous knowledge can be gained from observing and understanding the challenges faced each day on the front lines.[16] (For more information, see the box "Comprehensive Unit-Based Safety Program.")

SHEA Practice Recommendations summarize and prioritize CVC evidence-based practices, including the role of leadership and medical staff, and advise accountability at all levels of hospital staff. Leadership should support an adequately staffed infection prevention and control program, provide resources for education ensuring that all healthcare workers are trained and competent to perform job responsibilities, and hold personnel accountable for their actions. Hospital leaders can also empower nurses, physicians, and other healthcare workers trained in CVC insertion protocols to stop the insertion procedure if a break in aseptic technique is observed. Direct healthcare providers and ancillary staff must consistently apply appropriate infection prevention practices including hand hygiene protocols, standard and isolation precautions, equipment and environmental cleaning and disinfection practices, aseptic technique, and CVC insertion and maintenance evidence-based practices. The facility infection preventionist is responsible for active surveillance and analysis of CLABSI events, integration of evidence-based practices into the infection prevention program, and event reporting to hospital leaders and staff.[12]

The IHI introduced the CLABSI prevention toolkit and the bundle concept in 2005. The IHI Web site also has a detailed mentor section full of practical tips to help other hospitals achieve the same success. IHI leadership strategy examples include selection of a physician champion who acts as liaison to the medical staff and designation of unit-based nursing leaders who can maintain unit awareness of CLABSI prevention practices and outcomes. Nurses can be empowered to enforce the use of an insertion checklist to assure all processes related to central line placement are executed for each line insertion. Leadership support can be provided in the form of a written protocol that also identifies which hospital leader can be called to the scene if needed to enforce protocols. Letters sent to medical and nursing staff—signed by the ICU medical director, infectious disease physician, and the hospital chief executive officer—have been used to communicate leadership's commitment to CLABSI prevention. Standardization of protocols and communication flow is essential for successful programs.[17]

Education and Training

As of January 1, 2010, the Joint Commission requires that hospitals must implement CVC policies aligned with CDC and evidence-based standards and have an educational plan for healthcare workers, patients, and families. Healthcare workers involved in insertion care and maintenance must be educated about CLABSI prevention on hire, annually, or when added to job responsibilities.[15] SHEA strategies additionally recommend ensuring that clinicians who insert CVCs undergo a credentialing process as well as periodic assessment of knowledge and adherence to preventive practices.[12] IHI mentors suggest the development of an educational program, including elements such as an easily accessible paper or electronic education program with pre- and post-tests. Education and certifications should be based on evidence-based literature for CVC insertion and maintenance. Consider development of a competency checklist for staff in all areas where lines are inserted.[17] Lessons learned from analysis of CLABSI events should be disseminated to all stakeholders in the process.

CVC Insertion Protocols

CLABSIs associated with CVCs that occur within the first 10 days of insertion are most often correlated with extraluminal biofilm formation. The current prevention bundle focuses primarily on the prevention of extraluminal colonization, as the skin surrounding the insertion site is the primary source of bacteria colonizing the external catheter surface. The initial colonization occurs with attachment of bacteria to the catheter tip and the external catheter surface with passage through the skin during insertion and can

2008 Report: Healthcare-Associated Infections in Pennsylvania Hospitals

More than 13,000 healthcare-associated infections (HAI) were reported by Pennsylvania hospitals for a rate of 2.84 HAIs per 1,000 days of hospitalization in the last six months of 2008, according to initial data released in January 2010 by the Department of Health.[1] The report includes HAIs for each hospital, with an emphasis on urinary tract infections associated with the use of a catheter and bloodstream infections associated with the use of a central line. These infections are among the more common HAIs and were selected to measure trends over time and for hospital-to-hospital comparisons.

When compared to other areas of the nation, the overall rates of these infections were lower in Pennsylvania than elsewhere. The three most commonly reported HAIs in Pennsylvania were urinary tract infections, surgical site infections, and intestinal infections.

In February 2008, all hospitals began electronically reporting HAIs using the National Healthcare Safety Network. The Department of Health reported the data as required by Act 52, part of the Governor's Prescription for Pennsylvania, which calls for monitoring the occurrence of HAIs in all Pennsylvania hospitals and long-term care facilities, for implementing scientifically demonstrated interventions to reduce HAIs, and for limiting reimbursement for costs associated with the occurrence of HAIs. The goal is to control and eventually eliminate HAIs in healthcare institutions in the Commonwealth of Pennsylvania.

To read the full report, visit http://www.health.state.pa.us.

Note

1. Pennsylvania Department of Health. 2008 REPORT Healthcare-associated infections (HAI) in Pennsylvania hospitals [online]. 2010 Jan 13 [cited 2010 Jan 14]. Available from the Internet: http://www.health.state.pa.us.

therefore be prevented through effective hand hygiene, use of maximal sterile barriers and appropriate skin disinfection. The CDC draft *Guideline for the Prevention of Intravascular Catheter-Related Infections*, posted in the November 3, 2009, *Federal Register*, updates and expands evidence-based recommendations from the 2002 *Guideline for the Prevention of Intravascular Catheter-Related Infections*.[1] The guideline recommends the use of chlorhexidine skin disinfectant due to its persistence and effectiveness in decreasing colonization of the catheter in the presence of serum and skin flora at the catheter insertion site, citing that the combination of chlorhexidine with alcohol increases the kill rate and drying time.[18]

As of January 1, 2010, the Joint Commission requires hospitals to use a standardized supply kit or cart, catheter checklist, and a standard protocol for insertion. Hand hygiene must be performed prior to catheter insertion or manipulation, and femoral CVCs should not be inserted in adult patients unless other sites are unavailable. A chlorhexidine-based antiseptic must be used as insertion skin prep in patients older than two months of age.[15]

IHI strategies for implementation of these practice elements include posting hand hygiene reminder signs at the entrances and exits to the patient rooms. Another strategy is to initiate a campaign using posters of celebrated hospital doctors and employees to address such topics as using proper hand hygiene, recognizing optimal site contraindications on the catheter checklist, and allowing skin antiseptic solution time to dry up to two minutes before puncturing the site.[17]

The Catheter Insertion Checklist

Development and implementation of a catheter insertion checklist ensures and documents compliance with aseptic technique. A nurse, physician, or other trained healthcare worker should observe the process and fill in the checklist.[12] The checklist can be packaged with the kit or cart and is an appropriate tool to analyze compliance with process measures. The Authority's review of several existing checklists concluded that the following elements be considered when designing a facility-specific insertion checklist:

- Data field columns—lists items completed or done with reminder, and rationale for deviation from procedure.
- Before insertion section—includes information regarding site assessment, bundle elements completed, and full body drape in place.
- During procedure section—include documentation of maintenance of sterile field, maximal sterile barriers and drape change if contaminated.
- After procedure section—document the following actions: site cleansed with antiseptic agent; sterile gauze or transparent dressing applied; placement verified; facility-specific practices applied, such as a securement device, a chlorhexidine impregnated sponge or dressing, or lot number of the catheter.
- Physician competence requirement statement—include a statement noting requirement that physicians or intravenous team inserters must be credentialed to place CVC lines or the number of acceptable attempts prior to calling in another clinician.
- Procedure note—integrate physician documentation into the checklist by including site selection, insertion status, type of anesthesia, insertion site, the number of lumens, reason for line, type of line, and the number of attempts to pass the needle.
- Signatures section—document names of inserting clinician, supervising clinician, and nurse.

Care and Maintenance

Catheters that are in place for longer than 10 days are almost always associated with intraluminal biofilm. The internal and external surfaces of catheter hubs are the immediate portal of entry to the intraluminal surface of the catheter. Microbial biofilm on the intraluminal surface originate from microorganisms transported through contaminated injection ports, needleless connectors, stopcocks, and catheter hubs, overwhelming the immune system and leading to bloodstream infection. Hub colonization is a significant cause of CLABSI due to frequent opening and manipulation, contaminated healthcare workers hands, poor hand hygiene, improper glove use during tubing or connector changes, and the presence of blood or solutions in the hub. Unless the hub is adequately disinfected, microorganisms can gain entry into the intraluminal flow system through any contaminated portal or connector site. Once inside, contact with any internal surface component of the administration system (e.g., extension tubing, needleless connectors, hub, catheter surface) results in biofilm attachment. The infection source is usually colonization (biofilm) of the skin tract from the insertion site to the vein.[18] As of January 1, 2010, the Joint Commission requires hospitals to use a standard protocol to disinfect hub and catheter ports before access.[15]

Examples of clinical approaches to disinfecting catheter hubs, needless connectors, and injection ports are to scrub the port before every access with 70% alcohol or an alcohol/chlorhexidine preparation to reduce intraluminal contamination, as well as change gauze dressings every two days and transparent dressings at least every seven days. Dressings should be changed more frequently if soiled, loose, or damp. Administration sets and add-on devices are replaced “no more frequently than at 72 hours” but should be changed every 24 hours if used for blood or lipids.[1] IHI recommends daily review of CVC necessity to prevent unnecessary delays in removing lines that remain in place simply because they provide reliable access but are clearly no longer needed for care of the patient.[2] This review can be included as part of multidisciplinary rounds. Daily goal sheets are useful to assess appropriateness of lines and compliance with bundle elements. Use of documentation prompts for recording the date and time of line placement, as well as care and maintenance activities, will aid in monitoring process compliance. Care reminders available to staff on pocket and IV pump cards or signs prompt staff to complete clinical activities. Documentation can be simplified with checkboxes and electronic hard stops.[17]

Comprehensive Unit-Based Safety Program

Johns Hopkins’ Comprehensive Unit-Based Safety Program (CUSP) for prevention of central line-associated bloodstream infections (CLABSI) was designed to improve safety culture and learn from mistakes by integrating safety practices into the daily work of a unit or clinical area.[1] Pennsylvania hospitals are among a select group participating in a two-year collaborative to stop bloodstream infections through the use of CUSP.

General CUSP interventions are as follows:

- Evaluate safety culture using the Agency for Healthcare Research and Quality (AHRQ) Hospital Survey on Patient Safety Culture.
- Educate staff on the science of safety to develop a unit-level safety culture.
- Identify defects in care using the collective wisdom of frontline workers.
- Commit to executive partnership.
- Learn from one defect and implement one culture improvement tool per month.
- Remeasure culture annually, and submit data to AHRQ’s benchmarking database.

The five CUSP interventions specific to CLABSI are as follows:

1. Educate staff on evidence-based practices to reduce CLABSI.
2. Implement a checklist to ensure compliance with these practices.
3. Empower nurses to ensure compliance with the checklist.
4. Provide feedback on infection rates including at the unit level.
5. Implement monthly team meetings to assess progress.

A sample CLABSI toolkit, including daily goals sheet, insertion and maintenance checklists, and a cost calculator, is available online from the Johns Hopkins Quality and Safety Research Group at http://safercare.net.

Note

1. Johns Hopkins Quality and Safety Research Group. On the CUSP: stop BSI. Comprehensive Unit-Based Safety Program (CUSP) toolkit [online]. 2008 Nov [cited 2009 Oct 30]. Available from Internet: http://safercare.s3.amazonaws.com/support_media/docs/cusp/CUSP_Toolkit.doc.

Special Approaches

Special approaches are recommended for use in areas with unacceptably high CLABSI rates despite the implementation of prevention strategies.[12] These approaches are also recommended for patients with heightened risk for severe complications, limited venous access, or a history of recurrent CLABSI. Examples of special approaches appropriate for patients older than two months of age include bathing ICU patients daily with a chlorhexidine preparation or using antimicrobial or antiseptic impregnated CVCs, dressings impregnated with chlorhexidine, or antimicrobial lumen locks. A povidine-iodine preparation should be used in children younger than two months of age, as the safety or

Additional Resources Available

The Pennsylvania Patient Safety Authority has a collection of educational tools for reducing the risk of central line-associated bloodstream infections, available at http://patientsafetyauthority.org/EducationalTools/PatientSafetyTools/clabsi/Pages/home.aspx. Its resources include this article, educational video modules, and tools such as a central line checklist.

The Authority gratefully acknowledges contribution of sample tools from Evangelical Community Hospital and Roxborough Memorial Hospital.

efficacy of chlorhexidine in this age group is an unresolved issue, according to CDC guidelines.[1,19]

Process and Outcome Measures

Establishment of a method to measure compliance with CVC insertion and care processes is essential to identify strategies for improvement. The Authority's analysis of CLABSI events from Pennsylvania hospitals (all unit types), as reported to NHSN from July 2008 to March 2009, revealed a high percentage of Pennsylvania hospitals reporting that compliance with best practices in patients with CLABSI was not known.

The Joint Commission requires hospitals to conduct periodic risk assessments, measure CLABSI rates, monitor compliance with best practices, evaluate effectiveness of prevention efforts, provide rate data and outcome measures to key stakeholders, evaluate all CVCs routinely, and remove nonessential catheters.[15] Performance measures derived from published guidelines include measuring the percentage of compliance with the CVC insertion process as documented on an insertion checklist, daily assessment of continued need for the CVC, avoidance of femoral vein insertions, and observed cleaning of catheter hubs and injection ports before access. These numerators are divided by the total number of patients with a CVC in the unit population being assessed times 1,000 line days. Outcomes are measured by dividing the number of CLABSIs by the number of catheter days times 1,000 to express the measure in a rate.[12]

IHI mentors suggest strategies such as starting with one unit-specific pilot project; developing a facility-specific, standardized maintenance bundle; conducting bundle compliance reviews at several levels (e.g., infection prevention, administration); and issuing a certificate of appreciation for improvement. Another strategy to consider involves developing a method to share outcomes with the hospital peer review committee, the medical executive committee, the medical education program, nurse managers, and the governing board.[17] The hospital can measure its culture of safety using a survey developed by the Agency for Healthcare Research and Quality (https://www.patientsafetygroup.org/survey/index.cfm?sample=1). This survey may provide further insight into issues surrounding CVC processes and barriers. (See "Comprehensive Unit-Based Safety Program.")

Conclusion

CLABSI will continue to pose a serious threat unless prevention strategies are implemented and solutions to address the pathogenic mechanism associated with vascular access devices are discovered and implemented.[18] Effective strategies to prevent or control biofilm on medical devices must take into consideration the unique and tenacious nature of biofilm. Current intervention strategies are designed to prevent initial device colonization, minimize microbial cell attachment to the device, penetrate the biofilm matrix, kill the associated cells, or remove the device from the patient. Healthcare providers must adopt established best practices to reduce the risk of CLABSI and associated morbidity and mortality to reduce healthcare costs. Hospitals can accelerate the process by participating in collaborative efforts and networking with hospitals that have been successful in reducing infection rates such as IHI mentors.[17] The key to successful CLABSI reduction is to combine strategies from the available guidelines with the adaptive cultural changes necessary to achieve actionable sustainable results. Renewed focus from hospital leadership, physicians, and nurses is essential to promote a culture of zero tolerance for CLABSI and unsafe practices.

Notes

1. O'Grady NP, Alexander M, Dellinger EP, et al. Guidelines for the prevention of intravascular catheter-related infections. *MMWR Recomm Rep* 2002 Aug 9;51 (RR-10)1:29.
2. Institute for Healthcare Improvement. Getting started kit: prevent central line infections how-to guide. 2008 [cited 2009 Oct 30]. Available from Internet: http://www.ihi.org/IHI/Programs/Campaign/CentralLineInfection.htm.
3. Association for Professionals in Infection Control and Epidemiology. Targeting zero healthcare associated infections [position statement online]. 2008 July 18 [cited 2009 Oct 30]. Available from Internet: http://www.apic.org/AM/CM/ContentDisplay.cfm?ContentFileID=11707.
4. U.S. Department of Health and Human Services. Secretary Sebelius releases inaugural health care "success story" report [press release online]. 2009 July 13 [cited 2009 Oct 30]. Available from Internet: http://www.hhs.gov/news/press/2009pres/07/20090713a.html.
5. Mermel LA. Prevention of intravascular catheter-related infections. *Ann Intern Med* 2000 Mar 7;132(5):391-402.
6. Donlan RM, Costerton JW. Biofilms: survival mechanism of clinically relevant microorganisms. *Clin Microbiol Rev* 2002 Apr;15(2):167-93.
7. Ryder MA. Catheter-related infections: it's all about biofilm [online]. Top Adv Nurs 2005 Aug 18 [cited 2009 Oct 30]. Available from Internet: http://www.medscape.com/viewarticle/508109.

8. Scott RD. The direct medical costs of healthcare-associated infections in U.S. hospitals and the benefits of prevention [online]. 2009 Mar [cited 2009 Oct 30]. Available from Internet: http://www.cdc.gov/ncidod/dhqp/pdf/Scott_CostPaper.pdf.
9. Klevens RM, Edwards JR, Richards CL Jr, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. *Public Health Rep* 2007 Mar-Apr;122(2):160-6.
10. Umscheid CA, Mitchell MD, Agarwal R, et al. Mortality from reasonably-preventable hospital-acquired infections [advisory online]. [cited 2009 Oct 30]. Available from Internet: http://www.shea-online.org/Assets/files/0408_Penn_Study.pdf.
11. Medical Care Availability and Reduction of Error (MCARE) Act. 40 P.S. § 1303.401, et. seq. (2007).
12. Marschall J, Mermel LA, Classen D, et al. Strategies to prevent central line-associated bloodstream infections in acute care hospitals. *Infect Control Hosp Epidemiol* 2008 Oct;29 Suppl 1:S22-30.
13. Edwards JR, Peterson KD, Andrus ML. National Healthcare Safety Network (NHSN) report, data summary for 2006 through 2008. *Am J Infect Control* 2007 Dec;37(10):783-805.
14. Gurses AP, Murphy DJ, Martinez EA, et al. A practical tool to identify and eliminate barriers to compliance with evidence-based practices. *Jt Comm J Qual Patient Saf* 2009 Oct;35(10):526-32.
15. The Joint Commission. National Patient Safety Goals [2008 Goal 7:07.04.01 online]. [cited 2009 Oct 30]. Available from Internet: http://www.jointcommission.org/NR/rdonlyres/868C9e07-037f-433d-8858-0d5faa4322f2/0/revisedchapter_HAP-NPSG_20090924.pdf.
16. Johns Hopkins Quality and Safety Research Group. On the CUSP: stop BSI. Comprehensive Unit-Based Safety Program (CUSP) toolkit [online]. 2008 Nov [cited 2009 Oct 30]. Available from Internet: http://safercare.s3.amazonaws.com/support_media/docs/cusp/CUSP_Toolkit.doc.
17. Institute for Healthcare Improvement. Mentor hospital registry: central line infection [online]. [cited 2009 Oct 30]. Available from Internet: http://www.ihi.org/IHI/programs/campaign/mentor_registry_cli.htm.
18. Ryder M. Improve CRBSI prevention: target intraluminal risks [online]. Exec Health 2009 Jul [cited 2009 Oct 30]. Available from Internet: http://www.executivehm.com/article/Improve-CRBSI-Prevention-Target-Intraluminal-Risks.
19. Mermel L. New technologies to prevent intravascular catheter-related bloodstream infections. *Emerg Infect Dis* 2001 Mar-Apr;7(2):197-9.

PENNSYLVANIA PATIENT SAFETY ADVISORY

THE PENNSYLVANIA PATIENT SAFETY AUTHORITY AND ITS CONTRACTORS

An Independent Agency of the Commonwealth of Pennsylvania

The Pennsylvania Patient Safety Authority is an independent state agency created by Act 13 of 2002, the Medical Care Availability and Reduction of Error ("Mcare") Act. Consistent with Act 13, ECRI Institute, as contractor for the Authority, is issuing this publication to advise medical facilities of immediate changes that can be instituted to reduce Serious Events and Incidents. For more information about the Pennsylvania Patient Safety Authority, see the Authority's Web site at http://www.patientsafetyauthority.org.

ECRI Institute, a nonprofit organization, dedicates itself to bringing the discipline of applied scientific research in healthcare to uncover the best approaches to improving patient care. As pioneers in this science for nearly 40 years, ECRI Institute marries experience and independence with the objectivity of evidence-based research. More than 5,000 healthcare organizations worldwide rely on ECRI Institute's expertise in patient safety improvement, risk and quality management, and healthcare processes, devices, procedures and drug technology.

The Institute for Safe Medication Practices (ISMP) is an independent, nonprofit organization dedicated solely to medication error prevention and safe medication use. ISMP provides recommendations for the safe use of medications to the healthcare community including healthcare professionals, government agencies, accrediting organizations, and consumers. ISMP's efforts are built on a nonpunitive approach and systems-based solutions.