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WHITE PAPER

Healthcare-Associated Infections:
A Focus on Catheter-Related Bloodstream Infections

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The purpose of this white paper was to investigate the current situation that exists in regards to healthcare-associated infections (HAIs) with a specific focus on catheter-related bloodstream infections (CRBSIs). The information gathered for the white paper was used in the development of the needs assessment for the conference, the needs assessment for continuing education activities in HAI and the needs assessment for selecting panelists and conference speakers.

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INTRODUCTION

Healthcare-associated infections (HAIs) are an increasing problem and lead to substantial morbidity and mortality. These infections are generally defined as localized or systemic conditions that result from an infectious agent acquired during a hospital admission, and often occur in connection with a device such as a catheter or a ventilator.[1,2] Although HAIs are commonly thought of as hospital acquired, these infections can occur in all settings, such as same-day surgical centers, ambulatory outpatient clinics, the home setting, and long-term care facilities. These infections are among the leading causes of death in the U.S. As shown in data collected by the Centers for Disease Control and Prevention (CDC), the estimated number of HAIs in U.S. hospitals in 2002 was approximately 1.7 million. Urinary tract infections (UTIs) accounted for 32% of HAIs, surgical site infections (SSIs) for 22%, pneumonia for 15%, and bloodstream infections for 14%. Most of these infections (1.3 million) occurred outside of the intensive care unit (ICU). The CDC estimates that HAIs occur at a rate of 9.3 infections per 1,000 patient-days and 4.5 infections per 100 admissions. In addition, the CDC estimates that in 2002, 98,987 deaths were attributed to HAIs. Pneumonia was the leading cause of death (35,967), followed by bloodstream infections (30,665), UTIs (13,088), SSIs (8,205), and infections of other sites (11,062).

Catheter-related bloodstream infections (CRBSIs), resulting from either central or peripheral catheters, have been shown to increase hospital length of stay and ventilator days.[3] Data on mortality have been less consistent, with mortality rates attributed to CRBSIs ranging from 0% to greater than 30%. A study by Bolt and colleagues[3] showed that CRBSIs were associated with a 12-day increase in total duration of hospitalization, with 8 of these days spent in the ICU. Duration of mechanical ventilation also increased by 7 days in patients with CRBSIs.

In addition to the impact HAIs have on morbidity and mortality, these infections are associated with substantial healthcare costs. In a report released by Scott[4] from the CDC, it was estimated that HAIs are associated with $28.4 to $33.8 billion of extra healthcare costs annually.[4] This equates to a per-patient cost of $16,359 to $19,430. Scott also reported per-patient costs by site of infection and noted that SSIs ($11,087 to $29,443), CRBSIs ($6,461 to $25,849), and ventilator-associated pneumonia (VAP) ($14,806 to $27,520) had the highest costs for HAIs. He also estimated the cost savings that would be associated with preventing HAIs, noting that if 20% of infections were prevented, $5.7 to $6.8 billion would be saved. The potential savings amount to between $19.9 and $23.7 billion, given that at least 70% of infections are preventable.

These data show that HAIs are an enormous public health problem. Measures to prevent and eliminate these infections are essential. The purpose of this “white paper” is to provide an overview of HAIs, with a specific focus on CRBSIs. This review was prepared in advance of an HAI consensus conference on the prevention of CRBSIs that was held October 8 and 9, 2009.

Government response

In accordance with the Deficit Reduction Act of 2005, the Centers for Medicare and Medicaid Services (CMS) released a list of hospital-acquired conditions that were nonreimbursable.[5] The conditions were based on the National Quality Forum (NQF) list of “never events.” According to NQF, never events are defined as “errors in medical care that are clearly identifiable, preventable, and serious in their consequences for patients, and that indicate a real problem in the safety and credibility of a health care facility.” Examples of never events include surgery performed on the incorrect part of the body, a foreign object remaining in a patient after surgery, blood incompatibility, and severe pressure ulcers acquired in the hospital. As of October 1, 2008, 11 hospital-acquired conditions were identified as preventable and would no longer be paid for by CMS if the condition were listed as a secondary diagnosis and if no documentation existed to show that it was present on admission to the healthcare facility. In addition, hospitals that fail to report these events receive reduced payments. Four of the 11 conditions are HAIs: catheter-associated UTIs, SSIs occurring after select procedures, mediastinitis post coronary artery bypass graft (CABG) surgery, and CRBSIs.

In response to the threat of HAIs, the U.S. Department of Health and Human Services (HHS) in collaboration with other agencies such as the CDC and CMS has developed an action plan to reduce, prevent, and ultimately eliminate HAIs.[6] The HHS action plan, released in 2009, includes a list of top 10 messages on HAIs. These top messages include: most HAIs are preventable; a systematic approach to reducing transmission can be more effective than a disease-specific approach; studies are needed that will generate strategies to reduce the risk of HAI transmission; education of best practices for preventing HAIs for healthcare providers is essential; and education of patients and the media is also needed. Within the action plan, HHS has established national 5-year prevention targets for 6 HAIs: CRBSIs, catheter-associated UTIs, SSIs, VAP, *Clostridium difficile* infections, and methicillin-resistant *Staphylococcus aureus* (MRSA) infections. In addition, the action plan prioritizes recommendations from key guidelines on the prevention of select HAIs. The prioritized prevention strategies for CRBSIs will be highlighted below.

General prevention measures

Preventing HAIs begins with basic measures, such as hand hygiene. In 2007, the Healthcare Infection Control Practices Advisory Committee (HICPAC) released guidelines on preventing transmission of infectious agents in healthcare settings.[7] Standard precautions discussed in the guideline include hand hygiene ; the use of personal protective equipment, such as gloves, gowns, and masks; patient placement; care of equipment, instruments, devices, and the overall environment; and safe injection practices. Hand hygiene is recommended before any direct contact with patients, after contact with a patient's intact skin, and after contact with a patient's blood, body fluids, mucous membranes, nonintact skin, or wound dressings. Hand hygiene is also recommended if hands will be moving from a contaminated body site to a clean body site, after contact with inanimate objects (e.g., medical equipment) in the immediate vicinity of the patient, and after removing gloves. The guidelines recommend that hand hygiene be performed with either a nonantimicrobial or an antimicrobial soap and water. For hand decontamination, an alcohol-based hand rub is preferred. Personal protective equipment should be worn when contact with a patient's blood or body fluid may occur. The same pair of gloves should never be worn for the care of more than one patient. Masks, goggles, face shields, or a combination of these is recommended to protect the mucous membranes during patient-care activities that are likely to generate splashes or sprays of blood, body fluids, or secretions.

Patients who pose a risk of transmission of infectious agents to others should be placed in single-patient rooms when available.[7] The guidelines also recommend that policies and procedures be developed for containing, transporting, and handling patient-care equipment and instruments/devices, and for routine and targeted cleaning of environmental surfaces. Frequently touched surfaces, such as doorknobs and toilet fixtures, should be cleaned more often with disinfectants. Some general safe-injection practices recommended by HICPAC include the use of aseptic technique; never administering medications from a syringe to multiple patients, even if the needle or cannula is changed; the use of only single-dose vials for parenteral medications whenever possible; and storage of multidose vials away from immediate patient-care areas.

The guidelines also include recommendations on administrative responsibilities, education and training, surveillance, specific transmission-based precautions, and placement of patients in protective environments.[7] Healthcare administrators are encouraged to make prevention of transmission of infectious agents a priority for their organizations. Education and training of new and existing staff on preventative measures are recommended, in addition to close surveillance of HAIs. Healthcare facilities are encouraged to monitor the incidence of targeted HAIs and to analyze the data to identify trends and risk factors that will aid in the development of prevention and control strategies.

INTRAVASCULAR CATHETER-ASSOCIATED INFECTIONS

Risk factors for infection

Infection is just one potential complication of intravascular catheter use and a number of risk factors have been identified.[8,9] These include type and location of the catheter, certain patient factors, and the duration of catheter use.

Types of intravascular catheters—peripheral versus central

Intravascular catheters can be very broadly divided into peripheral and central, based on where the catheter terminates in the vasculature.[9] Peripheral catheters are commonly inserted through, and terminate in, the cephalic, basilic, or axillary veins, and they range in length from <3 to 8 inches.[9,10]

Several types of central catheters are available—nontunneled, tunneled, peripherally inserted, and implanted ports.[11,12] Although the different types of central catheters may enter the vasculature at different sites, they generally terminate in the superior vena cava.[12] Nontunneled central catheters are usually 6 to 8 inches in length and are inserted percutaneously into the subclavian vein; these are usually for short-term use.[9,12] Tunneled central catheters are placed through a subcutaneous tunnel, exiting the skin from the lower chest wall, and are designed for long-term use.[9-12] Tunneled catheters have a small synthetic cuff at the skin exit site. The cuff not only helps to secure the catheter in place, but also prevents migration of bacteria or other organisms from the skin into the catheter. Central catheters that are inserted via a peripheral vein (basilic, median cubital, or cephalic) and terminate in the superior vena cava are referred to as peripherally inserted central catheters or PICCs.[9,10] Implanted ports are the last type of central catheter.[9,12] As the name implies, these ports are completely implanted under the skin and are designed for long-term use.

Catheter type and risk of infection

The type and location of intravascular catheters are important determinants of the risk of infection. One of the larger analyses conducted to determine the risk of CRBSI with different types of catheters was done by Maki and colleagues.[13] The analysis included 200 published studies on the risk of infection with a number of different catheter devices (peripheral, central [nontunneled, tunneled, and PICCs], and implanted ports) as well as various patient groups and settings (intensive care, medical, surgical/trauma, hematology/oncology, acquired immunodeficiency syndrome, parenteral nutrition, and acute renal failure). The results are shown in Table 1. Based on duration of catheterization, nontunneled central catheters were shown to have the highest rates of CRBSI. However, the authors noted that all catheters carry some risk of CRBSI and that initiatives for infection control are needed for all catheter types.

Table 1. Rates of CRBSI by catheter type.[13]

Device type	Rates of BSI per 1000 IVD-days (95% CI); preferred reporting method	Rates of BSIs per 100 devices (95% CI)*
Peripheral	0.5 (0.2–0.7)	0.1 (0.1–0.2)
PICC	1.1 (0.9–1.3)	3.1 (2.6–3.7)
Nontunneled CVC	2.7 (2.6–2.9)	4.4 (4.1–4.6)
Tunneled CVC	1.7 (1.2–2.3)	4.7 (3.2–6.2)
Cuffed and tunneled CVC	1.6 (1.5–1.7)	22.5 (21.2–23.7)
Implanted ports central	0.1 (0.0–0.1)	3.6 (2.9–4.3)

BSI=bloodstream infection; CVC=central venous catheter; IVD=intravascular device; PICC=peripherally inserted central catheter.
*Reporting of rates as BSI per 1000 IVD days.

Catheter insertion site

The site of insertion for central catheters can influence the risk of infection. The optimal insertion site for central catheters is the subclavian vein.[14] This site has been associated with a lower risk of infectious complications compared with the internal jugular or femoral sites.Rates of infection with the jugular or femoral approaches have been reported to be 2 to 3 times higher compared with a subclavian site.[14.15] One recent surveillance study found the rates of CRBSIs to be 3.8, 6.1, and 15.7 per 1000 catheter days for subclavian, jugular, and femoral sites, respectively.[16]

Multi-lumen versus single-lumen catheters

Depending on the need, central catheters can be single-, or multi-lumen (i.e., double- or triple-lumen). Overall, multi-lumen catheters have been associated with a higher rate of infection compared with single-lumen types.[17] The risk appears to be slight based on an analysis of 15 studies that compared infection rates of single-lumen and multi-lumen catheters.[18] In addition, no increase in the risk of catheter colonization was seen. However, Templeton and colleagues[15] reported the number of lumens in a catheter to be a significant risk factor for infection, with a hazard ratio of 1.88 for each additional lumen present. Dobbins and colleagues[19] found that in patients with CRBSIs, 20% of those with triple-lumen catheters had significant microbial colonization in all 3 lumens, while 40% of those with double-lumen catheters had colonization in both lumens. The authors concluded that each lumen of a multi-lumen catheter should be considered as a potential source of a bloodstream infection.

Duration of use

Duration of central catheter use has been identified as a risk factor for bloodstream infection.[20,21] In an analysis of 2101 catheters observed over 20,981 patient days, duration of catheterization was found to be a significant independent risk factor for infection with a hazard ratio of 1.029 ($P \leq 0.017$).[22] However, current guidelines from the CDC do not recommend routine replacement of central catheters as a means to decrease the risk of infection.[9] In a meta-analysis, Cook and colleagues[23] found no significant difference in catheter colonization nor in infection rates with scheduled catheter change (every 3 days) compared with catheter change as needed or every 7 days. In addition, Badley and colleagues[24] reported higher infection rates for central venous pressure catheters that were changed (either new site catheters or catheters exchanged over a guidewire) compared with first-placement catheters (relative risk 3.6, $P \leq 0.001$).[24]

Patient factors

Various patient factors—in addition to catheter type, location, and duration—have been evaluated as risks for CRBSIs. Safdar and colleagues[20] identified 96 prospective cohort or randomized trials on risk factors for CRBSIs and found that the presence of acquired immunodeficiency disease, low CD4 cell counts, and neutropenia increase the risk of a CRBSI with noncuffed percutaneous central catheters. In addition, patients on a surgical service or on mechanical ventilation; transplant recipients; those with extended hospital stays, active infections at other sites, or with high APACHE scores; and patients with other intravascular devices were also at increased risk of a CRBSI. Yoshida and colleagues[25] conducted a 2-year prospective trial involving 1073 patients with a total of 29,221 device days. Based on a comparison of 66 patients with CRBSIs and 1007 patients with no infections, male sex and ICU stay were found to be factors significantly associated with an increased risk of infection. In a smaller study by Sreeramoju,[26] hypotension at first positive blood culture, prior vasopressor therapy (within 24 hours), and diabetes were significant factors in patients with CRBSIs following surgery. Other patient factors reported to increase significantly the risk of CRBSI include age, severity of illness, and impaired host defense mechanisms.[17]

Inpatients versus outpatient settings

Alternative settings, such as home care, have been associated with lower rates of CRBSIs.[13,27,28] In the analysis conducted by Maki and colleagues,[13] 15 studies included patients with PICC lines. Of these, 9 addressed the use of PICCs in the outpatient setting. It was noted that among inpatient and outpatient settings, the inpatient rate was 2.1 bloodstream infections (BSIs) per 1000 intravascular device days compared with a rate of 1.0 BSIs per 1000 intravascular device days for patients in the outpatient setting. Another study, by Graham and colleagues,[27] identified infectious complications among 300 patients receiving home infusion therapy through either peripheral or central venous catheters. The rate of bacteremia in these patients was 4.6 per 10,000 catheter days or 6.0 per 10,000 home care days. When expressed per 1000 home catheter days, the rate would be 0.59. Finally, a prospective, cohort observational study was performed to evaluate bloodstream infection rates for patients receiving home infusion therapy via either a central or peripheral venous catheter.[28] A total of 827 patients was followed over a 1-year period in 2 different sites. There were 69 CRBSIs that occurred over 69,532 catheter days, with calculations yielding a BSI rate of just less than 1 (0.99) infection per 1000 catheter days.

Types of infection

The use of intravascular catheters can result in both systemic and local infections either at the catheter exit site or the subcutaneous areas of a tunneled or implanted device.[11] CRBSIs are defined by signs of an infection (fever, chills, and/or hypotension) in the presence of an intravascular device and at least 1 positive blood culture taken from a peripheral site with no other sources of infection.[29] The same organism should be isolated from the catheter culture and from the peripheral blood culture.

Exit-site infections can manifest with erythema, induration, and tendernesss near (within ≤2 cm) the area of catheter exit.[29] Other signs of infection may be present, such as fever and purulent drainage from the catheter area. For tunneled catheters, an infection along the subcutaneous route may result in erythema and tenderness. Local infections (referred to as pocket infections) may also occur with implanted ports; tenderness, erythema, and induration may be present. Rupture of the skin area and necrosis may occur. These local infections—exit-site, tunnel, and pocket infections—may occur with or without a systemic bloodstream infection. Recent guidelines from the Infectious Diseases Society of America (IDSA) on the diagnosis and treatment of catheter-related infections recommend catheter removal, incision and drainage, and antibiotic therapy for tunnel or pocket infections (without bacteremia). Uncomplicated exit-site infections (e.g., no positive blood cultures) may be treated locally; however, systemic antibiotics and catheter removal may be needed if topical therapy is ineffective.

PREVENTION OF INTRAVASCULAR CATHETER-RELATED INFECTIONS

Governmental guidelines

Guidelines from the CDC, published in 2002 in association with HICPAC, address methods for prevention of any intravascular catheter-related infection, including local and bloodstream infections, as well as phlebitis, a catheter-related complication that may predispose a patient to infection (Table 2).[9]

The HHS action plan has identified 10 HICPAC-related recommendations for the reduction of CRBSIs as having priority.[6] These recommendations relate to aseptic technique for catheter insertion and care (including maximal barrier protection), use of an appropriate antiseptic at the insertion site (e.g., 2% chlorhexidine), selection of an appropriate catheter and insertion site with consideration of catheter-site complications during selection (e.g., pneumothorax, puncture, thrombosis, or catheter misplacement), use of the subclavian approach for a nontunneled central catheter, sterile gauze or transparent dressings, removal of any unused intravascular devices, and replacement of catheter dressing when damp, soiled, or loosened.

Recommendations from the Society of Healthcare Epidemiology of America (SHEA) and IDSA identify 3 areas for prevention of CRBSIs—prior to, during, and after catheter insertion.[30] Education of healthcare providers on proper technique for catheter insertion and proper catheter care and maintenance is recommended as an initial step for preventing CRBSIs prior to catheter-insertion procedures. During catheter insertion, a checklist is recommended to ensure compliance with established policies and aseptic technique. Other recommendations include appropriate hand hygiene and maximal barrier precautions, avoidance of the femoral site, use of a chlorhexidine-based antiseptic for skin preparation, and use of a catheter kit or cart for needed supplies. After catheter insertion, all catheter entry sites (hubs, needleless connectors, and injection ports) should be disinfected before each use with either an alcoholic chlorhexidine preparation or 70% alcohol, with regular site care (using a

Table 2. CDC and HICPAC recommendations for prevention of intravascular catheter-related infections.[9]

Recommendation	Description
Site of catheter insertion	Infection risk: subclavian preferred over jugular or femoral Phlebitis risk: hand veins < wrist/upper arm < lower extremity
Hand hygiene	Waterless, alcohol-based product Antibacterial soap and water with adequate rinsing
Aseptic technique	Short peripheral catheters: gloves with "no-touch" technique Central catheters (including PICCs and midline catheters): maximal barrier precautions
Skin antisepsis	Chlorhexidine 2% preferred 10% povidone iodine, 70% alcohol, or tincture of iodine acceptable
Catheter site dressing regimens	Transparent dressings = gauze dressings for rate of colonization Gauze may be preferred for oozing sites Change dressings at least weekly (every 2 days for gauze dressings) for short-term central catheters; no more than once weekly for tunneled/implanted devices until healed No recommendation for healed long-term cuffed/tunneled catheters Do not use topical antibiotic creams/ointments
Catheter securement devices	Sutureless may be preferred over sutured securement for rates of CRBSIs
In-line filters	Reduce incidence of infusion-related phlebitis, but no data on efficacy in reducing CRBSI
Antibiotic/antiseptic impregnated catheters and cuffs	Minocycline/rifampin lower rates of CRBSI than chlorhexidine/silver sulfadiazine Use of either treated catheter based on the need to enhance existing CRBSI precautions Balance use against costs and risk of resistant pathogens
Prophylactic systemic antibiotics	No data on benefit Consider risk of resistant pathogens (especially vancomycin)
Catheter replacement	Short peripheral catheters: replace at least every 72-96 hours to reduce infection and phlebitis risks Other catheters: routine replacement not necessary Remove any unneeded catheters
Administration set replacement (including add-ons and secondary sets)	Change no more often than every 72 hours More frequent changes for infusions that may enhance antimicrobial growth (e.g., lipids or blood products)
Needleless intravascular devices	Change at least as frequently as administration set Change caps no more than every 72 hours

PICC=peripherally inserted central catheter; CRBSI=catheter-related bloodstream infection.

chlorhexidine-based antiseptic) and dressing changes. In addition, administration sets should be replaced at intervals of no longer than 96 hours (excluding sets for blood products or lipids), with surveillance for CRBSIs.

Additional guidelines

Several non-US professional organizations have developed guidelines to help prevent HAIs, including CRBSIs. The epic2 are evidence-based guidelines developed for use in National Health Service hospitals in England.[31] These guidelines describe precautions and practices to be implemented in 3 areas: infection control practices, short-term indwelling urethral catheters, and central venous access devices. Although many of the recommendations are similar to those found in US guidelines, epic2 provides more detailed procedures for hand hygiene, with 3 stages of an effective hand hygiene technique described—preparation, washing and rinsing, and drying. In addition, epic2 stresses the importance of removal of any jewelry or other items on the hands and wrists (e.g., nail extensions or false nails) that may interfere with effective hand hygiene, as well as the use of waterproof dressings for any cuts or abrasions on the hands. Another concept (similar to aseptic technique) advocated in literature from the United Kingdom, is the aseptic non-touch technique (ANTT).[32] With ANTT, the main principle is to avoid contact of any sterile part of a product or device (referred to as a key part) with any surface or object that is non-sterile. For example, key parts of a syringe that should not come into contact with any nonsterile surfaces or objects include the syringe tip and plunger, the hub of the needle, and the any portion of the needle.

Other initiatives—The team approach and education

One intervention that has been used to reduce CRBSIs is the team approach.[33] The team concept has been applied in a number of different ways, ranging from a dedicated infusion therapy team for catheter care to a team-leader model, in which physicians and nurses are trained in methods of CRBSI prevention and then work in collaboration with infection-control practitioners to implement preventative interventions.[33-35] Overall, the team approach has been shown to be effective in reducing rates of CRBSIs. Another approach is provider and patient education.[30] The SHEA guidelines recommend that resources be available to provide appropriate education and training to clinicians who insert and maintain catheters. Healthcare personnel should be required to complete an educational program to ensure their knowledge and competency before being allowed to insert CVCs. Patient and family education is also essential, especially for patients and caregivers who are taking care of their own catheters in alternative settings such as home care.

Best practices—Central line bundles

Care bundles—groupings of individual best practices—have been developed for prevention of several HAIs, including CRBSIs.[36-38] Referred to as the central line bundle, this grouping of individual best practices has been shown to result in reduced rates of CRBSIs, with better outcomes seen with the bundle compared with each practice individually. The central line bundle includes 5 individual practices derived from HICPAC guidelines: hand hygiene, maximal barrier precautions upon central catheter insertion, chlorhexidine skin antisepsis, optimal site selection for catheter placement (subclavian for nontunneled catheters and avoidance of the femoral site), and daily review of line necessity (with removal of any unneeded lines). At an ICU in one institution, implementation of a central line bundle resulted in reduction of CRBSIs from 10.77 to 1.67 per 1000 central line days over a 3-year period.[38]

Devices used to prevent catheter-associated infections

In addition to measures such as appropriate catheter insertion, care, and maintenance as outlined in the described guidelines and central line bundles, various devices are available that may help to reduce the risk of catheter-associated infections, including CRBSIs.

Prevention of catheter occlusion secondary to blood reflux

Occlusion of intravascular catheters is a common complication and may increase the risk of catheter-related infections.[39] Timsit and colleagues[40] reported that thrombotic complications with central catheters were associated with a significant increase in the risk of catheter colonization or septicemia (relative risks of 1.64 and 3.22, respectively; $P<0.05$). Raad and colleagues[41] investigated the relationship between thrombotic complications of central catheters and infection using postmortem examinations. Autopsy results from 72 cases found the rate of CRBSIs to be 23% among 31 patients with mural thrombosis of a catheterized vein compared with no cases among 41 patients without a catheter thrombosis.

Catheter occlusions may be either thrombotic or non-thrombotic. Thrombotic occlusions can occur at several sites on the catheter, including in the lumen of the catheter or on the catheter tip.[42] Several factors can influence the risk of thrombus formation, such as catheter material, catheter tip location, and duration of catheter use.[39] In addition, improper technique of catheter flushing and reflux of blood into the catheter contribute to thrombus formation in the catheter lumen.

Anti-reflux devices

Several catheters are available that are designed to reduce the risk of blood reflux into the catheter. Valved catheters have a closed tip with a 3-way valve that opens when either negative (aspiration) or positive (infusion) pressure is applied.[43,44] However, when the catheter is not in use and no pressure is applied, the valve remains closed, preventing reflux of blood into the catheter. For catheters such as a Groshong, the valve is a slit at the distal end of the catheter tip.[45,46] In other catheters, such as the Vaxcel PICC, the valve is in the external hub of the catheter and functions similarly.[47] A third valved catheter design is the PowerPICC. This catheter has the 3-way valve in the catheter hub and has the capacity for power injection.[48] In addition to valved catheters, add-on devices are available for preventing blood reflux. The Lifeshield TKO is a pressure-activated anti-reflux device that contains a dome-shaped valve within the connector.[49] The domed valve remains closed with no fluid flow, and opens forward or in reverse for a fluid flush or aspiration, respectively.

Valved devices have been shown to be effective in reducing the risk of catheter occlusions. Hoffer and colleagues[50] conducted a prospective study to compare the rates of complications between valved and nonvalved PICCs. The study included 362 patients, with a mean catheter use of 34 days. During the study, catheter-related infections or catheter occlusions occurred in 12 patients with valved catheters compared with 26 given nonvalved catheters (*P*=0.02). The individual rates of catheter occlusion and infection were lower with the valved catheter, although the differences did not reach statistical significance. In a smaller study, Carlo and colleagues[51] compared complications of a valved implanted port with a nonvalved port. Although there were no differences in the rates of infectious complications or thrombosis between the 2 devices, patients in the valved-port group had significantly fewer episodes of difficulty in withdrawing blood (3% vs. 6.1%, *P*=0.05) or in the inability to withdraw blood (5.8% vs. 11%, *P*=0.02) compared with the nonvalved-port group. Total time to ensure port patency was also lower with the valved port (750 vs. 1545 minutes, *P*<0.03).

Antiseptic barrier caps

An antiseptic barrier cap for use with needleless valve connectors has been developed to provide better disinfection of the septal surface of the needleless connector.[52] When threaded onto a Luer-adaptable needleless connnector, an antiseptic-filled capsule (containing 2% chlorhexidine gluconate in 70% isopropyl alcohol) saturates a sponge between the capsule and the valve septum, disinfecting the septal surface. The sponge stays in contact while the cap is in place; after removal of the cap, the septum does not require disinfection prior to use. An *in vitro* study found the antiseptic barrier cap reduced contamination significantly more than disinfection with 70% alcohol on precontaminated needleless valve connectors.[52]

Antimicrobial-coated/impregnated catheters

The use of central catheters that have been coated or impregnated with antimicrobials has been investigated as a means to reduce the incidence of CRBSIs.[53,54] The rationale for the use of treated catheters is related to biofilm formation within the catheter. A biofilm is composed of multiple bacteria species that adhere to the catheter surface.[53] Catheters treated with antimicrobial agents are thought to modify the catheter surface to prevent adherence of the biofilm, thus reducing the risk of infection. The antimicrobial agents used have primarily been chlorhexidine-silver sulfadiazine or minocycline-rifampin. In a recent systematic review, Gilbert and Harden[55] reviewed data from 37 randomized clinical trials, with 11,586 patients. Seven of the studies compared antibiotic-impregnated catheters (primarily minocycline-rifampin) to standard central catheters. Based on pooled data (involving 1747 patients), the minocycline-rifampin–treated catheters were associated with a significant reduction in the risk of bacteremia compared with standard catheters (RR 0.28 [95% CI, 0.15-0.54]). The risk of catheter colonization was also reduced with these catheters (RR 0.38 [95% CI, 0.21-0.70]). More studies were available that compared chlorhexidine–silver sulfadiazine–coated catheters to standard catheters—17 with 4366 patients. However, a reduction in the risk of catheter colonization was seen only with the coated catheters—RR 0.58 (95% CI 0.43-0.77)—in comparison with standard catheters. Current SHEA/IDSA recommendations state that these treated catheters should be considered for institutions or units with higher-than-goal rates of CRBSIs or for patients with a history of CRBSIs.[30] A new catheter type, not addressed in current guidelines, uses a biomimetic coating.[56] This coating is said to mimic the naturally occurring glycocalyx layer in the endothelial tissue and reduce thrombus formation within and external to the catheter.

SUMMARY

The impact of HAIs on morbidity, mortality, and healthcare expenditures is substantial. When assessing the impact of CRBSIs specifically, these infections have been shown to increase hospital length of stay, mechanical ventilation days, and mortality. These infections are also associated with some of the highest increases in additional healthcare costs. Therefore, healthcare providers must familiarize themselves with risk factors for CRBSIs and ways to prevent or reduce their occurrence. Following standard precautions such as proper hand hygiene, use of personal protective equipment, and safe injection practices is the first step in preventing CRBSIs. Once general preventative measures are followed, providers must focus on specific CRBSI prevention strategies, such as using aseptic technique during catheter insertion, proper catheter-site maintenance, and use of specific devices to prevent CRBSIs. Having an understanding of the many factors that affect the occurrence of CRBSIs will aid in the development of prevention and control strategies.

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