IN PRACTICE

Epidemiology, Surveillance, and Prevention of Bloodstream Infections in Hemodialysis Patients

Priti R. Patel, MD, MPH, Alexander J. Kallen, MD, MPH, and Matthew J. Arduino, DrPH

Infections cause significant morbidity and mortality in patients undergoing hemodialysis. Bloodstream infections (BSIs) are particularly problematic, accounting for a substantial number of hospitalizations in these patients. Hospitalizations for BSI and other vascular access infections appear to have increased dramatically in hemodialysis patients since 1993. These infections frequently are related to central venous catheter (CVC) use for dialysis access. Regional initiatives that have shown successful decreases in catheter-related BSIs in hospitalized patients have generated interest in replicating this success in outpatient hemodialysis populations. Several interventions have been effective in preventing BSIs in the hemodialysis setting. Avoiding the use of CVCs in favor of access types with lower associated BSI risk is among the most important. When CVCs are used, adherence to evidence-based catheter insertion and maintenance practices can positively influence BSI rates. In addition, facility-level surveillance to detect BSIs and stimulate examination of vascular access use and care practices is essential to a comprehensive approach to prevention. This article describes the current epidemiology of BSIs in hemodialysis patients and effective prevention strategies to decrease the incidence of these devastating infections.

Am J Kidney Dis 56:566-577. Published by Elsevier Inc. on behalf of the National Kidney Foundation, Inc. This is a US Government Work. There are no restrictions on its use.

INDEX WORDS: Bacteremia; catheter-related infections; dialysis; epidemiology; infection control.

This is the second of 2 articles discussing infection prevention in hemodialysis units; the first article focused on the epidemiology, surveillance, and prevention of hepatitis C virus infections, and this article focuses on bloodstream infections.

CASE PRESENTATION

At their monthly quality improvement meeting, clinical staff in an outpatient hemodialysis center noted that 4 patients treated in the facility had required hospital admission during the previous month for bloodstream infections (BSIs). Each of the 4 patients had been undergoing hemodialysis at the center for at least 8 months. At the time, 3 patients were being dialyzed through tunneled central venous catheters (CVCs). Methicillin-susceptible Staphylococcus aureus had been isolated from blood cultures from 2 patients. Escherichia coli had been isolated from blood cultures from the third patient, and blood culture results were unknown for the fourth patient. Although BSI rates were not being systematically measured at the facility, a review of positive blood culture reports that had been recorded in a logbook for the past several years confirmed that it was unusual for the center to have more than one patient with positive blood culture results in a month.

Facility staff initiated a root-cause analysis and aggressively followed up other patients’ blood culture results, reasons for antibiotic administration, and hospitalization records to determine whether other BSIs had occurred. Blood culture results for the fourth patient eventually were identified as positive for S. aureus, but lacked antimicrobial susceptibility test results; no other episodes of bacteremia were identified in facility patients. When examined, the prevalence of CVC use in facility patients appeared to be unchanged over time. A nurse manager reported that several clinical staff had been hired in the prior 3 months and was unsure whether proper catheter care practices were uniformly followed by all staff. The facility consulted with a local infection preventionist to assist in a more thorough review of their catheter care and infection control practices.

Catheter care practices at the facility were reviewed on different shifts and days. A number of suboptimal practices were identified, including use of a skin antiseptic solution different from that called for in the facility’s procedure manual (2% chlorhexidine), failure to consistently perform hand hygiene and wear clean gloves before initiating vascular access care, and failure to adequately disinfect catheter hubs. Use of antimicrobial ointment at catheter exit sites also was inconsistent. Upon questioning, several staff reported that they had stopped using antimicrobial ointment because...
it was not included in the catheter dressing kits. In response, the facility conducted infection control in-service training for all staff, instituted regular audits of hand hygiene and catheter care practices, and included essential supplies in catheter care kits. The facility also decided to enhance BSI surveillance efforts by collecting data on this and other outcomes through the Centers for Disease Control and Prevention’s (CDC’s) National Healthcare Safety Network (NHSN) and incorporated surveillance data reports into subsequent quality improvement meetings.

**EPIDEMIOLOGY IN HEMODIALYSIS PATIENTS**

Infections, including BSIs, are a major cause of hospitalization and remain the second leading cause of death in patients undergoing hemodialysis. National data from the US Renal Data System (USRDS) show that hospitalizations for infection in hemodialysis patients increased 34% from 1993 to 2006, whereas all-cause hospitalization rates were relatively stable during this period. The actual number of BSIs that occur in US hemodialysis patients is not known, but has been estimated to be at least 50,000 per year. Nationally, BSIs resulted in 103 hospital admissions/1,000 hemodialysis patient-years in 2006. This rate was higher than that for pneumonia (76 admissions/1,000 patient-years) or cellulitis (26 admissions/1,000 patient-years). The USRDS also has documented a 105% increase in total admissions for vascular access infection from 1993 to 2006.

BSIs in hemodialysis patients can be life threatening and are associated with substantial morbidity and cost. One study identified chronic kidney disease requiring hemodialysis as the strongest risk factor for developing a severe BSI (ie, BSI resulting in intensive care unit admission) with a relative risk of 209 (95% confidence interval [CI], 143-296). Hemodialysis patients who were studied after an inpatient admission for a BSI caused by *S aureus* required hospitalization for an average of 9-13 days; complications such as endocarditis and osteomyelitis were common, occurring in 21%-31% of patients. In a prospective single-center study, Engemann et al reported that the mean cost of treating a BSI caused by *S aureus* was $24,034 per episode. The mean cost of initial hospitalization was significantly greater for patients with complicated versus uncomplicated *S aureus* BSI in this study ($32,462 vs $17,011; \text{P} = 0.002$). In a large retrospective analysis of USRDS data, Nissen-son et al found that complications of *S. aureus* BSI were associated strongly with both increased costs and duration of hospital stay. Twelve-week mortality following *S aureus* BSI in the cohort of Engemann et al of mostly catheter patients was 19%. Li et al studied only patients with a graft or fistula and similarly found 12-week mortality after a *S. aureus* BSI in this subgroup to be 20%.

Infective endocarditis is a particularly devastating complication of BSI in hemodialysis patients. In a retrospective study that examined hemodialysis patient outcomes over 10 years, 1.4% of patients developed infective endocarditis; 59% of the affected patients had a CVC. In 2 studies, in-hospital mortality in hemodialysis patients with infective endocarditis was approximately 50%.

As with many health care–associated infections, the incidence of BSI in hemodialysis patients varies by facility and invasive device use. Several studies have reported summary estimates by combining data from dialysis centers. CDC’s NHSN includes a dialysis event surveillance component (www.cdc.gov/nhsn/psc_da_de.html) that reports pooled mean rates of BSI, stratified by vascular access type, from participating facilities. NHSN uses patient-months as the denominator (instead of catheter-days or patient-sessions) for simplicity of data collection and to allow comparison of rates across vascular access types.

The risk of BSI in patients with a CVC is substantially higher than for those with other forms of vascular access. In the 2006 NHSN report, the overall BSI rate for patients with temporary (nontunneled) CVCs was 27.1 events/100 patient-months compared with 4.2 for patients with permanent (tunneled) CVCs, 0.9 for those with arteriovenous (AV) grafts, and 0.5 for those with AV fistulas. Similarly, the BSI rate for patients with CVCs was 41.6 events/100 patient-years (~3.5 events/100 patient-months when units are converted) in a study by Dopirak et al compared with 1.5 events/100 patient-years (~0.13 events/100 patient-months) for patients with AV grafts or fistulas.

Although BSI rates in those with tunneled CVCs in the studies described are approximately 4 events/100 patient-months (~1-2 events/1,000 catheter-days, when units are converted), a higher BSI incidence in patients with catheters has been.
reported in other studies. Rates in patients with CVCs in the control groups of several antimicrobial catheter lock trials have ranged from 3-4 events/1,000 catheter-days (≈10.5 events/100 patient-months), showing variability across centers. This variability is evident even among facilities that define BSI and collect rate information in a uniform manner.

**Pathogens**

The most common organisms identified in studies of BSI in hemodialysis patients include staphylococci and other gram-positive cocci. In general, coagulase-negative staphylococci are identified most commonly (32%-45% of BSIs), followed by *S aureus* (22%-29%) and enterococci (9%-13%). Gram-negative bacilli have been reported in 21%-30% of BSIs. The organisms isolated in patients with BSI appear to vary by vascular access type. The proportion of BSIs caused by *S aureus* might be higher in patients with AV fistulas or grafts, whereas coagulase-negative staphylococci have been reported more frequently in patients with catheters. Gram-negative bacilli also were more common in patients with CVCs versus AV fistulas or grafts. Hemodialysis patients are at high risk of some infections caused by multidrug-resistant organisms. Population-based surveillance data collected through the CDC’s Emerging Infections Program show that dialysis patients are 100 times more likely to acquire an invasive infection caused by methicillin-resistant *S aureus* than individuals in the general population. In 2005, dialysis patients accounted for 15% of all invasive infections caused by methicillin-resistant *S aureus* reported to CDC. Most (86%) of these infections were BSIs; associated rates of hospitalization (90%) and in-hospital mortality (17%) were high. Of 126 methicillin-resistant *S aureus* isolates from dialysis patients in this study, 80% of strains were of health care origin and 14% were community strains (USA100 and USA300 accounted for 74% and 13% of isolates, respectively).

**Risk Factors**

The risk factor most strongly associated with BSI is vascular access type. A multicenter study of incident hemodialysis patients found that compared with patients with AV fistulas, the age-adjusted relative risk for developing a BSI in patients with AV grafts was 1.69 (95% CI, 0.42-6.79); with cuffed/tunneled CVCs, 9.78 (95% CI, 3.53-27.11); and with noncuffed CVCs, 10.54 (95% CI, 3.69-28.20). These findings are in line with incidence rate data from NHSN in terms of the potential magnitude of increased risk associated with CVCs relative to AV fistulas.

**PREVENTION MEASURES**

A number of interventions have been suggested to prevent BSIs in dialysis patients, several of which are listed in Table 1. This section describes commonly used interventions and evidence surrounding their use.

**Reducing Catheter Use**

The low occurrence of BSI associated with AV fistulas has been an important driver of efforts such as the Fistula First Breakthrough Initiative, which aims to increase AV fistula use in prevalent hemodialysis patients. From 1998 through 2006, the percentage of patients in the End-Stage Renal Disease (ESRD) Clinical Performance Measures Project who were dialyzed using AV fistulas increased from 26% to 45%. However, during the same period, use of catheters for longer than 90 days increased from 14% to 22%. Overall catheter use in this nationally representative sample reached 29% in 2006. Data reported by Fistula First suggest that catheter use has been relatively stable since 2003, possibly peaking in 2006-2007. More recently, these data provided the first indication of a potential downward trend in catheter use.
The excessively high BSI risk in catheter patients together with national data indicating an overall increase in catheter use during the past 15 years emphasizes the urgent need to substantially decrease CVC use. It is possible that an increased prevalence of CVC use might reflect modifications in health care practices or a changing patient population with respect to age or disease states that can impact on vascular access options. Regardless of the underlying reasons, increased CVC use will contribute to the burden of BSIs and related complications in this population if allowed to continue. The preventable fraction of CVC use in this population is unknown and may be higher than expected.

Most patients initiate dialysis therapy using a CVC. Patients who receive pre-ESRD nephrology care are more likely to initiate dialysis therapy using an AV fistula than a CVC. However, hurdles to achieving functional permanent access exist even when patients undergo pre-ESRD care and vascular access planning. As with efforts to increase fistula rates, successful catheter reduction likely involves interventions that can be implemented within the dialysis setting, as well as a multidisciplinary systems approach to address external barriers. Successful decreases in CVC use have been shown after a multifaceted intervention to improve vascular access and a coordinated strategy to decrease

<table>
<thead>
<tr>
<th>Intervention</th>
<th>CDC26,27</th>
<th>KDOQI28,29</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid central venous catheter use for vascular access</td>
<td>Recommended</td>
<td>Recommended</td>
<td>CDC also recommends prompt removal of an intravascular catheter that is no longer needed.</td>
</tr>
<tr>
<td>Conduct surveillance for bloodstream infections</td>
<td>Recommended</td>
<td>Recommended</td>
<td>Review and feedback of surveillance data are an important part of this intervention</td>
</tr>
<tr>
<td>Educate and train health care personnel on catheter care and aseptic technique</td>
<td>Recommended</td>
<td>Recommended</td>
<td>Use of gloves does not eliminate the need for hand hygiene</td>
</tr>
<tr>
<td>Perform hand hygiene before accessing catheter</td>
<td>Recommended</td>
<td>Recommended</td>
<td></td>
</tr>
<tr>
<td>Wear surgical mask during catheter connect, disconnect, and dressing change procedures</td>
<td>No recommendation</td>
<td>Recommended</td>
<td></td>
</tr>
<tr>
<td>Preferentially use chlorhexidine for skin antisepsis</td>
<td>Recommended</td>
<td>Recommended</td>
<td>70% alcohol and povidone-iodine are alternative skin antiseptics also recommended by CDC and KDOQI</td>
</tr>
<tr>
<td>Apply antimicrobial ointment to catheter exit site</td>
<td>Recommended</td>
<td>Recommended</td>
<td>Povidone-iodine ointment is recommended by CDC. CDC recommends against the use of mupirocin ointment because of the risk of developing resistance. KDOQI recommends use of either povidone-iodine or mupirocin ointment. Some ointments might not be compatible with certain catheters</td>
</tr>
<tr>
<td>Routinely administer intranasal antimicrobials for <em>Staphylococcus aureus</em> decolonization</td>
<td>Recommended against</td>
<td>No recommendation</td>
<td></td>
</tr>
<tr>
<td>Routinely use antimicrobial-impregnated catheters</td>
<td>Recommended against</td>
<td>No recommendation</td>
<td></td>
</tr>
<tr>
<td>Use chlorhexidine-impregnated catheter dressings</td>
<td>No recommendation</td>
<td>No recommendation</td>
<td></td>
</tr>
<tr>
<td>Routinely use prophylactic antimicrobial catheter locks</td>
<td>Recommended against</td>
<td>No recommendation</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CDC, Centers for Disease Control and Prevention; KDOQI, Kidney Disease Outcomes Quality Initiative.
wait times for permanent access placement. Patient education was a component used by Asif et al\textsuperscript{34}; improving patient knowledge and the consent process may be important means of influencing vascular access selection and long-term patient preferences.\textsuperscript{36-38} Future quality improvement initiatives should examine and report changes in CVC rates and/or duration of use to better characterize effective interventions in this area. Further examination of data from USRDS and other sources also is warranted to understand reasons for the potential net increase in CVC use and whether this has contributed to the increase over time in hospitalizations for infection. Finally, efforts such as Fistula First should target decreases in all CVC use, not just CVC use for longer than 90 days, as a better reflection of patient risk. Ultimately, quality improvement efforts must be expanded to address CVC reduction goals.\textsuperscript{33,39}

Surveillance

Active collection and use of surveillance data is a critical part of any BSI prevention program and is recommended by the CDC.\textsuperscript{26} Conducting surveillance allows facilities to know their infection rates and recognize patterns of infection that might warrant intervention. Several published reports have shown this benefit of performing surveillance in dialysis settings.\textsuperscript{21,40,41} CDC’s NHSN system offers a free internet-based surveillance platform that facilities can use to record and track several outcomes, including BSI (Box 1). The system also allows participating facilities to compare their rates with other facilities nationally. NHSN dialysis event measures are based on information that is simple to collect, in contrast to definitions frequently used for clinical diagnoses or research purposes. Use of this surveillance system has facilitated decreases in BSI rates, antimicrobial use, and hospitalizations, while requiring minimal staff time.\textsuperscript{42} Through the new Centers for Medicare & Medicaid Services (CMS) Conditions for Coverage, all ESRD facilities are required to conduct surveillance for infections, particularly vascular access infections.\textsuperscript{43} However, standard reporting measures and methods have yet to be determined. Uniform validated measures, such as those in NHSN, are needed for rate comparability\textsuperscript{23} and to facilitate regional or national prevention initiatives (Table 2). Recently, Colorado became the first state to implement mandatory reporting of BSIs and other events from outpatient dialysis facilities; NHSN is the standard reporting tool for this effort. The experience in Colorado and national initiatives to address health care–associated infections in outpatient populations likely will accelerate efforts to identify and promote standard measures for infection surveillance and prevention.

Catheter Care

In patients who require CVC access, optimal insertion and maintenance practices are necessary to prevent BSI. Adherence to proper hand hygiene and glove-changing practice is poor in dialysis center staff, including at critical times, such as before and after handling the vascular access site.\textsuperscript{44,45} Hand hygiene should always be performed (using soap and water or an alcohol-based hand sanitizer) immediately before direct
contact with the CVC or other vascular access site, and clean or sterile gloves should be used for these activities. For insertion site skin antisepsis, chlorhexidine-based preparations have decreased catheter colonization and catheter-related BSIs compared with povidone-iodine. For this reason, both CDC and National Kidney Foundation Kidney Disease Outcomes Quality Initiative (KDOQI) preferentially recommend use of chlorhexidine for skin antisepsis for catheter insertion and exit-site care.

Catheter-site dressings generally are changed 1-3 times weekly, but also should be changed when they become wet, soiled, or loose. Two meta-analyses failed to show a significant difference in BSI rates when use of transparent film was compared with dry gauze dressings. Use of either dressing type is recommended for catheter exit sites. Chlorhexidine-impregnated dressings have been studied as a potential catheter-related BSI prevention measure. Two recent randomized controlled trials conducted in acute-care settings and focused on short-term nonhemodialysis catheters have shown significant decreases in catheter-related BSIs. In a study targeting children with tunneled hemodialysis catheters, Onder et al found that the addition of a chlorhexidine-impregnated sponge dressing to skin cleansing with povidone-iodine did not significantly decrease the rate of catheter-related BSI, although

### Table 2. Surveillance Measures for Dialysis Facilities

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
<th>Measurable Using NHSN</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcome Measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSI</td>
<td>No. of BSIs per unit of patient time^a</td>
<td>Yes</td>
<td>Often stratified by vascular access type; catheter-days sometimes used as denominator when measured in only patients with CVCs; BSIs might be defined differently in different surveillance systems; pathogen and antimicrobial susceptibility patterns frequently are monitored</td>
</tr>
<tr>
<td>Antimicrobial starts</td>
<td>No. of intravenous antimicrobial courses initiated per unit of patient time^a</td>
<td>Yes</td>
<td>In addition, can measure use of specific antimicrobials (ie, vancomycin)</td>
</tr>
<tr>
<td>Hospitalizations</td>
<td>No. of overnight hospital admissions per unit of patient time^a</td>
<td>Yes</td>
<td>NHSN monitors all hospitalizations, regardless of indication</td>
</tr>
<tr>
<td>Local access-site infections</td>
<td>No. of vascular access site infections per unit of patient time^a</td>
<td>Yes</td>
<td>Usually evidence of local infection in the absence of BSI</td>
</tr>
<tr>
<td>Pyrogenic reactions</td>
<td>No. of reactions per unit of patient time^a</td>
<td>No</td>
<td>Often defined by clinical features (eg, fever, shaking chills) and the absence of positive blood cultures</td>
</tr>
<tr>
<td><strong>Process Measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand hygiene adherence</td>
<td>Of all observed opportunities for which hand hygiene was indicated, percentage in which hand hygiene was successfully completed</td>
<td>No</td>
<td>Hand hygiene audit tools are simple to create and can be tailored to the dialysis environment</td>
</tr>
<tr>
<td>CVC use</td>
<td>Percentage of patients with CVC</td>
<td>Yes</td>
<td>All CVCs should be counted regardless of duration of use</td>
</tr>
<tr>
<td>Adherence to CVC insertion practices</td>
<td>Percentage of total insertions that included adherence to all recommended practices</td>
<td>Yes</td>
<td>NHSN’s CLIP module can be used to measure adherence to insertion practices during placement</td>
</tr>
</tbody>
</table>

Abbreviations: BSI, bloodstream infection; CLIP, Central Line Insertion Practices; CVC, central venous catheter; NHSN, National Healthcare Safety Network.

^aFor example, patient-months.

^bItems in the CLIP module include the following: (1) hand hygiene performed, (2) adherence to maximal sterile barrier precautions, (3) skin antiseptic, and (4) insertion site.
the incidence of exit-site infections decreased. Of note, in a follow-up study, these investigators found that changing povidone-iodine to 2% chlorhexidine for skin antisepsis (while continuing to use chlorhexidine-impregnated sponge dressings in both segments of the study) led to a significant decrease in catheter-related BSIs and associated hospitalizations. Currently, chlorhexidine-impregnated dressings are not recommended for routine use by CDC or KDOQI.

In 2000, KDOQI had recommended soaking catheter hubs or blood tubing connectors in povidone-iodine for 3-5 minutes before separating them. However, there appears to be little evidence to support this practice. In the observational study of children with tunneled hemodialysis catheters mentioned previously, the combination of topical povidone-iodine skin cleansing, chlorhexidine dressing, and soaking the catheter hubs in povidone-iodine was inferior to a regimen of 2% chlorhexidine gluconate with alcohol skin cleansing, chlorhexidine dressing, and cleansing the hubs with chlorhexidine for 1-3 minutes for the prevention of catheter-associated BSI. In the 2006 KDOQI update, soaking hubs with povidone-iodine is not mentioned; instead, cleansing catheter hubs with chlorhexidine is recommended.

Some alcohol-based antiseptics might damage polyurethane catheters when there is prolonged contact between the antiseptic solution and catheter material. Concerns regarding catheter compatibility might hinder the use of recommended antiseptic agents, such as chlorhexidine, for exit site or catheter cleansing. Although there are some data to dispute compatibility concerns, the issue of potential risk to catheter integrity associated with short-term exposure to alcohol-containing antiseptic agents under real-world conditions should be addressed definitively by catheter manufacturers to inform and facilitate adherence to recommended best practice. Although sodium hypochlorite solutions are commonly used for skin antisepsis and catheter cleansing in dialysis facilities, limited data are available to support their effectiveness for decreasing infections. Currently, these agents are not included in CDC or KDOQI recommendations.

**Antimicrobial Ointments**

Use of topical antimicrobial ointment at the catheter exit site has decreased the rate of BSI in dialysis patients with CVCs. Topical povidone-iodine ointment applied to nontunneled catheter exit sites decreases exit-site infections and BSIs and has been recommended by CDC and KDOQI. Similar results were identified in a study of topical mupirocin ointment for prevention of *S. aureus* exit-site infections and BSIs. In a study of tunneled catheters, mupirocin ointment at the catheter exit site led to a decrease in exit-site infections and catheter-associated BSIs, as well as delayed time to the first BSI. A randomized clinical trial involving patients with cuffed catheters assessed an antibiotic ointment containing polymyxin B, bacitracin, and gramicidin and showed a decrease in BSIs, as well as a survival advantage for patients in the intervention versus placebo group. In a trial that compared medical grade honey with mupirocin ointment, similar rates of catheter-associated infections were observed in the 2 groups.

Despite substantial supporting evidence, use of antimicrobial ointment at the catheter exit site appears to be an underutilized prevention measure within dialysis facilities. As with skin antiseptics, concerns regarding compatibility with catheter material may be a factor. For example, ointments containing polyethylene glycol might not be compatible with some polyurethane catheters. Distributing simplified information to providers regarding ointments that are both recommended and compatible with commonly used catheter materials likely would facilitate uptake.

**Antimicrobial Catheter Lock Solutions**

Multiple studies have evaluated the use of antimicrobial catheter lock solutions to prevent BSIs in hemodialysis patients. Agents that have been studied include antibiotics, such as gentamicin (with and without citrate), cefotaxime, cefazolin (with gentamicin), and vancomycin (with gentamicin), and nonantibiotic antimicrobial agents, such as citrate with and without taurolidine. Many of the studies have been summarized in 4 recent meta-analyses which concluded that antibiotic catheter lock solutions decrease catheter-related BSIs by 60%–70%. One meta-analysis evaluated nonantibiotic antimicro-
bacterial locks separately and found about a 50% decrease in catheter-related BSIs associated with the use of these lock solutions. However, this result was limited by significant heterogeneity among studies; the greatest observed effects were from studies that combined antimicrobial locks with additional prophylactic measures.

The summarized results of these studies have several important limitations. Few large trials have been conducted, which limits the availability of high-quality data to determine the true effect size of the agents studied; a funnel plot in one of the meta-analyses suggested both a small-studies effect and likely publication bias among the included studies. Most studies were conducted in populations with higher than expected BSI rates (3–4 events/1,000 catheter-days), bringing into question the value of antibiotic catheter locks in facilities with lower BSI rates. Many studies did not use currently recommended practices for BSI prevention in their control and intervention arms (eg, chlorhexidine skin antisepsis and antimicrobial ointment at the exit site) or these concurrent measures were not adequately described to permit assessment of cofactors. In one meta-analysis, the summarized risk reduction from studies of topical antibiotic ointment use was similar to that identified for antibiotic lock solutions. An acknowledged limitation in all studies was inadequate assessment of the development of antimicrobial resistance and other adverse effects of lock solutions.

The long-term consequence of using antibiotics routinely in catheter lock solutions is unknown. Based on the information available to date, large-scale resistance to agents used in catheter lock solutions has not been identified. However, a recent observational study found a trend toward increasing gentamicin resistance in coagulase-negative staphylococci at a facility after initiating use of gentamicin locks. Although results of antimicrobial lock studies appear promising, both antibiotic and nonantibiotic antimicrobial solutions warrant additional study before being considered for widespread use. Additional practical challenges include the lack of head-to-head comparison trials to determine superior lock solutions and, perhaps most importantly, the lack of approval by the US Food and Drug Administration of any antimicrobial lock solution for this use. As a result, most of these solutions are not packaged for this indication. These relatively large single-use containers are at risk of microbial contamination when used for more than one patient and not handled and prepared under conditions that meet sterile pharmaceutical compounding standards (typically not available in most dialysis centers). Currently, CDC recommends against the routine use of antimicrobial lock solutions for the prevention of catheter-related BSIs. In their most recent guidelines, KDOQI did not make a recommendation regarding use, but suggested that long-term studies of antimicrobial locks are needed.

Antimicrobial-Impregnated Catheters

Another approach to decrease BSI risk has involved the use of CVCs impregnated with antimicrobials, such as silver sulfadiazine, or antibiotics, such as rifampin and minocycline. These impregnated catheters have been evaluated in patients undergoing hemodialysis, with mixed results. In one study, patients with acute renal failure were randomly assigned to receive either an antimicrobial-impregnated (with minocycline and rifampin) or unimpregnated catheter. Patients with minocycline-rifampin catheters were significantly less likely to develop catheter-related infections, including BSI and sepsis; however, catheters in this study were used for relatively brief periods (mean duration, 8 days in both groups). In a second randomized trial, silver-coated tunneled catheters were compared with noncoated catheters. The catheters in this study were in place for a mean of 92 days, but there was no significant difference in infection rates between the 2 groups. The use of antimicrobial-impregnated catheters has not been specifically recommended for use in the dialysis setting.

Implementing Best Practices

Moving beyond the impact of individual interventions, a number of recent initiatives have shown that successful implementation of groups or “bundles” of interventions can dramatically decrease rates of health care–associated infections. Two studies of large regional interventions focused on decreasing catheter-related BSIs in intensive care unit settings. In each of these efforts, a group of evidence-based interventions (eg, improved hand hygiene, use of full barrier
precautions during CVC insertion, chlorhexidine skin antisepsis, optimal catheter-site selection, and removal of catheters when no longer needed) was implemented. Through these initiatives, substantial decreases (>60%) in catheter-related BSIs were achieved in different intensive care unit types and in hospitals with varying patient populations across the involved regions. By showing dramatic and sustained decreases in BSI rates purely through improved adherence to recommended practice, these initiatives have debunked previously held beliefs that only a small fraction of health care–associated infections can be reasonably prevented. Dialysis care providers are faced with a similar opportunity to demonstrate the preventability of BSIs in their patient population, change perceptions regarding the inevitability of infections, and improve patient outcomes. CDC currently is partnering with facilities interested in developing and implementing a group of evidence-based interventions to decrease BSIs in this setting.80

SUMMARY AND FUTURE DIRECTIONS

Hemodialysis patients, particularly those with CVCs, continue to be at heightened risk of serious morbidity and mortality resulting from BSIs. Current data suggest that rates of hospitalization for these infections have increased; changes in CVC use over time may have contributed to this trend. Multiple evidence-based interventions to prevent BSI in this setting are available and appear to be underutilized. These include conducting surveillance, optimizing hand hygiene practices and aseptic technique for catheter insertion and maintenance, and using chlorhexidine skin antisepsis and antimicrobial ointment. In addition, a concerted effort to decrease CVC use is critically needed and should be considered a patient safety and quality improvement priority. Patient education and engagement should be an important component of CVC-reduction efforts. For patients who require a CVC, new interventions, such as antimicrobial catheter lock solutions, are promising but warrant further study. Future evaluations of lock solutions should focus on the incremental effect of antimicrobial catheter locks over interventions already recommended for BSI prevention and should more systematically examine the risk of adverse events, including antimicrobial resistance development.

Strategies aimed at improving adherence to currently recommended evidence-based practices have the potential to dramatically decrease BSIs and other infections in this setting. The success of such strategies will continue to require input and buy-in of direct patient care staff to recognize barriers to implementation and develop local solutions to overcoming these barriers. Greater emphasis is needed nationally as well as within individual facilities on capturing process and outcome measures to ensure that interventions are being implemented successfully and have the anticipated result. The burden of disease in this population should stimulate all of us to demand aggressive BSI prevention efforts as an expected part of routine patient care.

ACKNOWLEDGEMENTS

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Financial Disclosure: The authors declare that they have no relevant financial interests.

REFERENCES


40. Taylor GD, McKenzie M, Buchanan-Chell M, Challo L, Chui L, Kowalewska-Grochowska K. Central venous


68. Al-Hweish AK, Abdul-Rahman IS. Successful prevention of tunneled, central catheter infection by antibiotic lock...
therapy using vancomycin and gentamicin. 


