Volume 18 • Number 3 • July 2019

NephSAP®

Nephrology Self-Assessment Program

Infection Control and Prevention in Outpatient Hemodialysis Facilities

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ASN
American Society of Nephrology

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Preface

NephSAP® is one of the premiere educational activities of the American Society of Nephrology (ASN). Its primary goals are self-assessment, education, and the provision of Continuing Medical Education (CME) credits and Maintenance of Certification (MOC) points for individuals certified by the American Board of Internal Medicine. Members of the ASN receive *NephSAP* electronically through the ASN website by clicking on the *NephSAP* link under "Education and Meetings" tab.

EDUCATION: Medical and nephrologic information continually accrues at a rapid pace. Bombarded from all sides with demands on their time, busy practitioners, academicians, and trainees at all levels are increasingly challenged to review and understand new and evolving evidence. Each bimonthly issue of *NephSAP* is dedicated to a specific theme, i.e., to a specific area of clinical nephrology, hypertension, dialysis, and transplantation, and consists of an editorial, a syllabus, and self-assessment questions, to serve as a self-study device. Over the course of 24 months, all clinically relevant and key elements of nephrology will be reviewed and updated. The authors of each issue digest, assimilate, and interpret key studies published since the release of the previous issues and integrate this new material with the body of existing information. Occasionally a special edition is produced to cover an area not ordinarily addressed by core issues of *NephSAP*.

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This paper meets the requirements of ANSI/NISO Z39.48-1921 (Permanence of Paper), effective with July 2002, Vol. 1, No. 1.

NephSAP®

Volume 18, Number 3, July 2019

Editorial

119 **Central Venous Catheters and Central Line–Associated Bloodstream Infections: The Best Prevention Is Elimination**
Daniel Landry

Syllabus

125 ***NephSAP* Volume 18, Number 3, July 2019—Infection Control and Prevention in Outpatient Hemodialysis Facilities**
Eduardo Lacson Jr. and Alan S. Kliger

126 **Learning Objectives**

126 **Epidemiology of Infections in Hemodialysis Patients Trends in Infection in Hemodialysis Patients**

126 Trends in Vascular Access–Related Infections

129 Treating Vascular Access–Related Infections as Healthcare-Associated Infections

130 The Convergence of Policy and Practice: Preventable Infections Are a Matter of Patient Safety

132 **Systems Approach in Implementation of the National Safety Strategy**

132 Understanding Systems Thinking and Applicability to Dialysis

132 The Nephrologist's Role in the Outpatient Hemodialysis Facility "System"

133 The Role of Team Members in the Outpatient Hemodialysis Facility System

135 Leading the Infection Prevention QAPI Process in the Outpatient Hemodialysis Facility

137 Building a Culture of Safety—Foundational for the Success of Human Systems

139 **Universal Infection Prevention Strategies Applied to Outpatient Hemodialysis Facilities**

139 Standard Precautions: Hand Hygiene

140 Standard Precautions: Personal Protective Equipment

142 Standard Precautions: Respiratory Hygiene/Cough Etiquette

142 Standard Precautions: Injection Safety

143 Transmission-Based Precautions: Droplet, Contact, and Airborne Precautions

144 Vaccination for Influenza

145 Vaccination for Pneumococcal Disease

150 **Specific Prevention Strategies for Outpatient Hemodialysis Facilities**

150 Environmental Cleaning and Disinfection

152 Vascular Access Care

152 Reducing Infections

152 Arteriovenous Fistulas and Grafts

153 Buttonhole Technique

154 Central Venous Catheters

154 Exit Site Care

155 Update on Antimicrobial Locks and Caps for Hemodialysis Central Venous Catheters

160 Hepatitis B in Hemodialysis Patients

163 Hepatitis C Virus Infection in Hemodialysis Patients

164 Human Immunodeficiency Virus Infection in Hemodialysis Patients

165 *Mycobacterium Tuberculosis* in Hemodialysis Patients

168 Multidrug-Resistant Organisms in Hemodialysis Patients

169 Antibiotic Stewardship in Hemodialysis Patients

170 Approach to Fever in the Hemodialysis Setting

173 Water Treatment in the Outpatient Hemodialysis Facility

176 Compiling Best Practices to Prevent Bloodstream Infections in the Dialysis Setting

178 **Other Infection-Related Issues, Disaster Preparedness, and Resources for Outpatient Hemodialysis Facilities**

178 State Healthcare-Associated Infection Programs

179 Preparedness for Emerging Threats

180 Herpes Zoster in Hemodialysis Patients

181 Bed Bugs in Hemodialysis Patients

182 Head Lice in Hemodialysis Patients

184 Patient Education and Engagement

NephSAP®

Volume 18, Number 3, July 2019

186 **Natural Disasters and Disaster Preparedness**
186 Goals
186 Preparedness
186 **Resources**
186 Water
187 Hand Hygiene
187 Peritoneal Dialysis
187 Infection-Related Processes and Protocols
187 Waste
187 Centers for Medicare & Medicaid Services Guidance
188 **Acknowledgement**

CME Self-Assessment Questions

191 **NephSAP Volume 18, Number 3, July 2019—Infection Control and Prevention in Outpatient Hemodialysis Facilities Examination**

Upcoming Issues

Chronic Kidney Disease and Progression
Holly J. Kramer, MD and Sankar D. Navaneethan, MD
September 2019

Transplantation
John P. Vella, MD and Alexander C. Wiseman, MD
November 2019

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Volume 18, Number 3, July 2019

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Volume 18, Number 3, July 2019

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July 2019

CME Credit Termination Date

June 30, 2021

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NephSAP®

Volume 18, Number 3, July 2019

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Volume 18, Number 3, July 2019

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Editorial

Central Venous Catheters and Central Line–Associated Bloodstream Infections: The Best Prevention Is Elimination

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In this issue of NephSAP, infection control is the topic. Although it is not the most attractive of topics to many nephrologists, those with experience as medical directors and those who have been exposed to the "risk world" of ESRD seamless care organizations can attest to the importance of understanding not only the regulatory responsibilities that we as nephrologists assume as part of our duties but also the opportunities for us to improve the quality of life of our patients who experience hemodialysis (HD) access infections. A now universal and permeating question is this: How can we prevent infectious complications from central venous catheters (CVCs)? Better yet, how can eradicate CVCs? This editorial will review the history of CVC use in HD, list the reasons for their prevalence, and provide a potential solution set for reduction of their undesirable prevalence.

Since the advent of modern HD in 1943 when Willem Kolff treated a "29-year-old housemaid suffering from malignant hypertension" using a rotating drum kidney and venipuncture needles placed in the femoral artery and reinfusion of the blood via vein, our specialty and our patients have faced the challenge of achieving safe and effective dialysis access (1). As Cimino, Brescia, and others pioneered arteriovenous (AV) anastomoses, a third individual brought forward the idea of the HD catheter. Dr. Stanley Shaldon confronted the problem of "finding a surgeon willing to operate on the radial artery and cephalic vein to introduce cannulae for circulatory access." Shaldon literally took matters into his own hands by hand-making catheters for introduction into the femoral artery and vein by a modified, percutaneous Seldinger technique. He concluded: "Eventually, veno-venous catheterization was preferred because the bleeding from the femoral vein was less than from the femoral artery when the catheter was removed" (2).

The Elephant in the Room: Central Venous Catheters and the Current State of Central Line–Associated Bloodstream Infections

Fast forward to the 21st century. There are now more than 511,000 patients receiving dialysis in the United States, with ages and comorbidities never likely envisioned by our nephrology predecessors. Despite the Fistula First Breakthrough Initiative in 2003, 36% of AV fistulas (AVFs) never mature, and 80% of incident ESRD HD patients still begin treatment with a tunneled CVC. After 1 year, catheter prevalence in the United States remains at approximately 20% (3). The National Healthcare Safety Network has reported that HD CVCs are more likely to cause central line–associated bloodstream infections (CLABSI) than are AVFs and AV grafts (AVGs) by factors of 8.4 and 4.7, respectively (4). The estimated financial cost of a CLABSI event is $45,000 (5). Beyond the financial costs, the human cost is even more staggering because the all-cause mortality rate of CLABSI in HD patients ranges anywhere from 12% to 25%. Up to 20% of all cases are associated with metastatic complications, including endocarditis, septic arthritis, and epidural abscesses. Metastatic infections have been observed in approximately 5% to 10% of HD-related CLABSIs and are more common when *Staphylococcus aureus* is involved. Delayed presentation may occur months following the resolution of a CLABSI event (6,7).

Current Evidence in the Prevention of Central Line–Associated Bloodstream Infections

The "Dialysis Safety Core Interventions," published by the Centers for Disease Control and Prevention (CDC) Dialysis Collaborative in 2016, was composed of a care bundle that included staff training,

meticulous hand hygiene, and surveillance. The Collaborative advocated for best practices for vascular access care, chlorhexidine gluconate (CHG) skin preparation (superior to aqueous and alcohol-based povidone-iodine solutions for reducing risks of catheter colonization and CLABSI), and "scrub the hub" catheter disinfection to reduce CLABSIs (8,9). Adoption of the care bundle resulted in a 54% reduction ($P<0.001$) in CLABSIs during the 15-month intervention period in 17 outpatient dialysis units (8). The application of these interventions to all dialysis units in the United States has since produced a dramatic reduction in CLABSIs in short-term studies (10). Exit site care with the use of antimicrobial ointment (povidone-iodine antiseptic ointment or bacitracin/gramicidin/polymyxin B ointment) following catheter insertion and at the end of each HD session has also been shown to reduce CLABSI rates. Consequently, exit site care is now intrinsic to the CDC's core interventions (8). Despite these successful interventions, CLABSI rates continue to be reported at 1.1 to 5.5 episodes per 1000 catheter-days (11). Thus, we are left asking ourselves what more we must do.

The Antimicrobial Lock: Is It the Solution?

All CVCs are colonized by microorganisms within 24 hours of insertion. These microorganisms enter by an extraluminal path (via skin and external catheter surface) and an intraluminal path. Adherence of organisms to both catheter surfaces initiates the production of an exopolysaccharide matrix that cossets the unwanted colonizers. This process ultimately leads to purposeful development of a microenvironment known to be highly resistant to systemic antibiotics: biofilm. Antimicrobial lock solutions (AMLs) contain high concentrations of an antimicrobial agent(s) with the ability to eradicate bacteria and their biofilms that coat the internal lumens of CVCs. The properties of an ideal AML, which can be either an antibiotic or a nonantibiotic solution typically mixed with an anticoagulant, should include adequate concentrations of antimicrobial agents to prevent CLABSIs without producing systemic toxicity, vascular thrombosis, or resistant bacteria (12).

Multiple AML strategies have emerged over the past decade. A recent Cochrane database meta-analysis of 39 studies and 4216 patients reported that AMLs (antibiotic and combined antibiotic plus nonantibiotic lock solutions) decreased the incidence of CLABSIs when compared with control lock solutions, generally heparin (13). The most commonly studied of these solutions has been gentamicin and heparin (or 4% citrate). Moore and colleagues (14) have reported the largest study to date consisting of a prospective, multisite, observational cohort of 555 HD patients constituting 155,518 catheter-days. The group compared a gentamicin/4% citrate AML with a conventional heparin locking solution during a 4-year interval. There was a 74% reduction in CLABSI rate during the AML period (0.45 events per 1000 catheter-days) compared with the heparin period (1.68 events per 1000 catheter-days; $P=0.001$). Regarding the universal concern for the generation of antibiotic resistance, this group demonstrated a reduction in the rate of production of gentamicin-resistant organisms from 0.40 per 1000 person-years for the heparin lock to 0.22 per 1000 person-years with the AML (15). By multivariable analysis, AML therapy compared with heparin locking was associated for the first time with a survival advantage (hazard ratio, 0.32; 95% confidence interval, 0.14 to 0.75). Moran and colleagues (16) have also published a randomized multicenter trial comparing a low-dose gentamicin-citrate lock (320 μg/ml of gentamicin in 4% citrate) with a standard heparin lock (1000 U/ml) in 303 HD patients over a 5-year period, during which time the CLABSI rate was significantly lower than the control rate. Like Moore and colleagues, the authors did not find an increase in gentamicin resistance during the protocol phase or subsequent 3 years.

More recent nonantibiotic AML solutions have focused on the use of taurolidine, trisodium citrate, and ethanol. In several studies, the antimicrobial taurolidine combined with citrate showed significant reductions in CLABSIs. However, there was evidence for increased catheter-related thrombosis (17). Trisodium citrate with anticoagulant properties has been used in a 4% concentrate as an AML. It has been independently studied at higher concentrations (30% or more) but has shown only mixed results in terms of CLABSI reduction (18). Ethanol has been popular for many years for catheter salvage with CLABSIs associated with peripherally inserted central catheters used for parenteral nutrition in pediatric patients. More recent data, summarized in a meta-analysis of 7 randomized controlled trials consisting of 2575 patients with 3375 catheter-days, indicated that ethanol significantly decreased CLABSI risk (relative risk, 0.54; 95%

confidence interval, 0.38 to 0.78; $P=0.001$) despite ongoing concerns regarding the potentially neurotoxic side effects of ethanol and the risk of damage to catheter integrity (19).

The nonantibiotic AML currently with greatest promise is a catheter cap containing an internal rod coated with CHG (ClearGuard, Pursuit Vascular, Maple Grove, MN). This U.S. Federal Drug Administration—approved CVC closure device forms a CHG AML when it comes in contact with a standard heparin locking solution, and CHG is coated along the catheter hub. Two industry-sponsored, prospective multicenter randomized controlled trials encompassing more than 533,000 catheter-days revealed a dramatic and sustained reduction in CLABSI rates, with no significant side effects. Although there is potentially a risk for CHG-induced hypersensitivity, the benefits of using ClearGuard may outweigh this miniscule risk. The device cost, borne by the dialysis provider, may be the main deterrent to widespread use (20,21).

A Global Strategy to Reduce Central Line–Associated Bloodstream Infections: What Should the Ideal Vascular Access Program Look Like?

Over the past 15 years, we have learned a great deal in terms of CVC management and CLABSI prevention. Nonetheless, nephrologists must offer their patients substantially more than our current reactive approach. A global view of CLABSI prevention must begin long before our patients receive their first HD access (Table 1). Such a view can end only when we arrive at a time when CVCs are no longer a viable option for any of our patients.

The education of physicians willing to lead the charge of catheter education and avoidance must begin early in a nephrology career. Experienced dialysis unit medical directors must accept their roles as educators of fellows-in-training regarding this important clinical domain. Beyond the nuances of individual patient care, nephrologists are *de facto* population healthcare managers with responsibilities of coordinating cost-effective, high-quality care for patients with advanced CKD and ESRD. The American Society of Nephrology (ASN) has initiated major steps to advance the education of nephrology trainees and new medical directors with the creation of "The Role of the Medical Director" series that appears in its journal, the *Clinical Journal of the American Society of Nephrology*. The ASN has established a strong relationship with the CDC and the Nephrologists Transforming Dialysis Safety Coalition (22,23). We must now build from these resources and lead our trainees by example with real-world practices. For example, during weekly rounds, engaged medical directors can demonstrate organizational commitment to developing a just and safe culture (24).

Table 1. Summary of global strategy for central venous catheter (CVC) reduction and central line–associated bloodstream infection (CLABSI) prevention.

- Greater focus in ***nephrology fellowship training regarding roles and responsibilities of the medical director*** (*Clin J Am Soc Nephrol* series, "The role of the medical director." The American Society of Nephrology and Centers for Disease Control and Prevention/National Transforming Dialysis Safety Coalition are both excellent resources).
- ***Chronic kidney disease teams*** for early access referral and education that are generally intended to assist patients and families with dialysis modality choices (to include palliative care options) but also provide the opportunity to involve pharmacists and social workers. Partnerships with local college programs can provide cost-effective relationships.
- Medical director leadership focusing on ***education and training of the dialysis staff*** using evidence-based practices surrounding CVC management.
- Use of ***antimicrobial lock solutions*** (antibiotic lock or non–antibiotic-based lock) or the use of antimicrobial catheter caps for the purpose of preventing CLABSI.
- Formation of a ***dedicated vascular access team*** that not only provides timely consultation and correction of dialysis access malfunction but also performs surveillance of dialysis catheter prevalence in dialysis units.
- Support for more ***vascular access-related research*** to improve the timeliness and quality of arteriovenous fistula maturation as we provide alternative alternatives to CVCs.
- Acceptance by the nephrology community to ***better educate and use advanced practice providers***.

It clearly is not enough to simply educate our future nephrologists and dialysis team members. A CKD team should exist in every nephrologist's office. Education must be taken to the patient with a focus on early intervention for the advanced CKD population. We have informed our primary care colleagues for years that the data support better patient outcomes when a nephrologist meets a patient at least 6 months before starting dialysis—but how many offices truly take advantage of these opportunities (25)? Are we as a specialty failing to counsel our patients regarding their choices (i.e., conservative care, dialysis modality options, timing for access placement, safe strategies to delay progression of kidney disease) in the advanced stages of CKD? Maybe the percentage of "crash" dialysis initiations with a CVC is a metric every bit as important as blood pressure and phosphorus control.

For patients who choose HD as their treatment modality, what can be done to help improve our dismal national AVF failure-to-mature (FTM) rates? In 2006, Lok and colleagues (26) published an externally validated formula to predict the AVF FTM rate. However, even patients with a low-risk classification incurred a 35% AVF FTM rate. High-risk patients had a 71% FTM rate. Preoperative duplex ultrasonographic findings of vein diameters from 2 to 3 mm have proved helpful in predicting successful AVF maturation. A recent study of 65 ESRD patients undergoing their initial AVF creation determined that intraoperative duplex ultrasonography after regional anesthesia-related vasodilation led to an average increase in intraoperative midforearm and distal forearm cephalic vein diameters of 0.96 mm ($P<0.001$) and 0.50 mm ($P=0.04$), respectively. This led to a more than twofold significant increase in radial artery–based access procedures and concomitant reduction of brachial-based AVF procedures and AVG procedures. Overall functional access rates were 63%, and the reported patency rates were comparable with those reported in the literature (27). The HD Fistula Maturation Study Group has been formed to research the science of AV access and how we can improve outcomes (28). The major goals of the group are these: 1) determining the utility of ultrasonography as a method for early identification of fistulas that are failing to mature, 2) evaluating the impact of pre-existing vascular function on fistula maturation outcomes, 3) identifying surgical factors that are associated with fistula maturation outcomes, 4) creating evidence-based criteria for fistula maturation, and 5) characterizing the clinical consequences of fistula maturation failure.

As outcomes from the HD Fistula Maturation Study Group are forthcoming, there remains other significant ongoing research. Efforts to standardize the anastomosis and flow characteristics of AVFs have been attempted since 1948, when the Swedish physician Alwall (29) cannulated rabbit carotid artery and jugular vein with silanized glass tubes. Shunt patency was maintained by a curved glass capillary bypass. Later, uremic patients received dialysis via the Alwall device. Success was short-lived, attributed to local infection and thrombosis, forcing abandonment of the technique.

More recently, a prosthetic implant composed of a nonthrombogenic siliconized polyurethane material functioning as an anastomotic conduit from artery to vein (Optiflow device, Bioconnect Systems, Fort Washington, PA) showed initial promise in a 2015 prospective controlled pilot study of 90-day unassisted maturation. However, the device did not provide superior unassisted maturation rates in a nonrandomized study of 41 patients and 39 matched control patients. Consequently, it was withdrawn from the commercial market (30,31). The VasQ (Laminate Medical Technologies, Israel) external metallic device creates a 60° anastomotic angle between artery and vein to optimize hemodynamic conditions. A single-center study of 20 patients reported 6-month primary patency and unassisted maturation rates of 79% and 74%, respectively. At the end of the follow-up time, 14 of 15 patients were able to use their AVFs for HD (32).

For individuals lacking suitable veins for AVF creation, Humacyte (Morrisville, NC) has created bioengineered veins on a tubular scaffolding from nonimmunogenic decellularized human cells. A multinational, double-armed, randomized phase 3 clinical trial comparing this bioengineered implantable tissue with standard AVGs in patients unsuitable for AVF creation is currently under way after the success of two separate 2012 single-arm phase 2 trials conducted in the United States and Poland. The results were 63% primary patency (defined as a functional access patency until any type of intervention to maintain or restore patency), 73% primary assisted patency (a vessel still functioning without occurrence of thrombosis), and 97% secondary patency (functional access patency, with or without preceding successful interventional or surgical procedures to maintain or reestablish patency, either until final failure or until the

vessel was abandoned) rates at 6 months (33). The current study's primary endpoint is secondary patency at 2 years with a 350-patient enrollment target (34).

Minimally invasive surgeries using the creation of a percutaneous AVF represent potentially novel approaches to better AVF maturation. The everlinQ endoAVF system (TVA Medical Inc., Austin, TX) is composed of two 6-French catheters that contain rare earth magnets. Magnetic alignment of catheters apposed in the ulnar artery and the ulnar vein is followed by radiofrequency-assisted construction of a side-to-side anastomosis. The success of this approach was documented in the 2017 NEAT trial, a prospective, single-arm, multicenter study. The 12-month primary and cumulative patency rates were 69% and 84%, respectively. There was an 8% rate of serious procedure-related adverse events (2% device related) (35). The Ellipsys Device (Avenue Medical, San Juan Capistrano, CA) is a single-unit endovascular device that creates a percutaneous AVF between a perforating forearm vein and radial artery following the application of direct low-power electrical current. In a nonrandomized multicenter study of 103 patients, 92 patients (89.3%) met the criteria for a usable AVF within 3 months after the procedure. Almost all patients (96.1%) required an additional procedure (such as balloon angioplasty) in the first 12 months to maintain AVF patency (36). The everlinQ system and the Ellipsys Device received U.S. Federal Drug Administration marketing approval in June 2018.

With much made about novel approaches to AVF construction, there has been little discussion regarding those who will provide vascular access services. Vascular access surgeons, interventional nephrologists, and interventional radiologists are all capable of performing many of these feats, but a common concern among nephrologists is the availability of requisite and dedicated support personnel who can be rapidly mobilized to avoid undesirable and unnecessary CVC placements. Nephrologists desperately need providers who can provide timely AV access mapping and creation and who can maintain adequate surveillance for maturation, conduct timely fistulography and/or thrombectomy for malfunctioning AV accesses, perform peritoneal catheter insertion, and maintain overall accountability of practice quality and outcomes. Within our practice environment, 5 transplant surgeons are dedicated to full-time vascular access care in a 716-bed academic hospital and outpatient vascular access center. CVC insertion during vascular access thrombosis is *verboten*, pending the availability of same-day or next-day vascular access surgery. Successful implementation of these rules has reduced the prevalent catheter rate to 6% across all 8 dialysis units in our practice; the catheter initiation rate is less than 20%. With ongoing reductions of financial reimbursement for vascular access procedures, the availability of access providers may be an existential dialysis crisis.

Finally, another well-recognized shortfall in nephrology is the notably small number of physicians willing to enter the specialty. The most recently reported fellowship match data show an ongoing gap in supply and demand for nephrology trainees. Ironically, a 2019 actuarial study predicts that the growth of the ESRD population in the United States will approach upward of 900,000 patients by 2030 (37,38). Clearly, nephrologists must do a better job of attracting, recruiting, training, and using advanced practice providers for the highly specialized and detail-oriented work inherent to medically complex dialysis patients. This represents a sea change from the conventional practice of using advanced practice providers as vehicles for conducting non-MCP dialysis rounding. The elevation of the role of advanced practice providers to nephrology dialysis access specialists and patient advocates should include, at the minimum, antibiotic stewardship rounding, management and oversight of CKD clinics/predialysis care, and management of urgent dialysis-related issues to sidestep unwarranted hospital admissions and readmissions.

There is much to celebrate when we consider the number of lives saved through the provision of kidney dialysis over the decades. However, with such pride comes recognition of unfulfilled promises, multiple failures, and more work to be done. As we inherit an older patient population with the burdens of many other chronic medical diseases, nephrology as a community must organize to meet the challenges of providing higher-quality care in a more cost-effective manner. Hemodialysis access remains the linchpin to fulfilling both of these demands. The elimination of the CVC is one goal upon which all of us must engage. In parallel, a global effort to streamline HD access care and expand the definition of the nephrology workforce must occur. Here, the enemy of "the good" is not "the better." Our patients are counting on us. Churchill's words decades later aptly state our plight: "Now this is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning."

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Syllabus

NephSAP Volume 18, Number 3, July 2019—Infection Control and Prevention in Outpatient Hemodialysis Facilities

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This issue of *NephSAP* is a special issue that addresses infection control and prevention in outpatient hemodialysis facilities. It represents collaborative work between the American Society of Nephrology (ASN) and the Centers for Disease Control and Prevention (CDC), through sponsoring Nephrologists Transforming Dialysis Safety (NTDS). As such, while the stylistic representation of *NephSAP* was followed, liberties were taken with regard to citations, in particular, to allow for this issue to serve as a foundational component of a larger curriculum being prepared by NTDS. Therefore, unlike other *NephSAP* products, it retains a more "review-like" format until it is updated in the future.

Consistent with the charge of NTDS under a collaborative agreement with CDC, the scope of this work has been intentionally limited to in-center hemodialysis. There are various reasons for this decision, including but not limited to 1) challenges posed by less-developed evidence-based recommendations for home dialysis (home hemodialysis and peritoneal dialysis) and 2) limitations imposed by the timetable of the NTDS cooperative agreement contracts between ASN and CDC. We hope that future work may address home dialysis settings.

Furthermore, some fundamental aspects of this work include key principles and protocols that otherwise would not be standard content in prior *NephSAP* updates. These include foundational knowledge on the Conditions of Coverage that are essential for regulatory compliance and thus, to the very existence of most if not all outpatient hemodialysis facilities. The CDC recommendations on Standard Precautions form another pillar of this work that needs to be included in detail. Another bedrock component is the NTDS thesis that a culture of safety is essential to establish a high reliability organization to address the key issue of infection prevention/control in this setting and that leadership by the nephrologist is required to build this safety culture. Moreover, NTDS recognizes that leadership needs to be cultivated and developed for nephrologists and Medical Directors so that the inclusion of foundational knowledge in systems thinking and situational awareness become prerequisites. Although this section is not specifically concerned with infection, we believe it is required for nephrologists and Medical Directors who will create cultures of safety to eliminate preventable infections. Of note, given that access-related infections remain a significant contributor to the morbidity and mortality related to infections, there is overlap between the information provided in the Epidemiology of Infections and the Universal Infection Prevention Strategies sections. This serves to emphasize salient points in the earlier section in order to focus on the rationale for specific recommendations in Universal Infection Prevention Strategies.

On behalf of the entire NTDS organization, the editor thanks the *NephSAP* Co-Directors, Editor, staff,

and reviewers for their excellent contributions and insightful commentaries.

Learning Objectives

1. To delineate the epidemiology and impact of infections on patients treated with maintenance hemodialysis and the development of a national safety strategy.
2. To describe a systems approach for implementation of the national safety strategy to prevent and decrease infections in patients treated at outpatient hemodialysis facilities.
3. To discuss implementation of universal infection prevention strategies that apply to outpatient hemodialysis facilities.
4. To elucidate infection prevention strategies specifically adapted for outpatient hemodialysis facilities.
5. To examine other infection-related issues, including emerging problems, disaster preparedness, and available resources that support infection prevention and control implementation in outpatient hemodialysis facilities.

Epidemiology of Infections in Hemodialysis Patients

Trends in Infection in Hemodialysis Patients

Infections rank second only to cardiovascular diseases (CVD) among known causes of death in patients with end-stage renal disease (ESRD) treated by maintenance hemodialysis (HD) (1). By 2016, according to the United States Renal Data System (USRDS), hospitalizations from (non–vascular access—related, NVA) infections equaled those from CVD, the two disorders cited as the most frequently reported reasons for hospital admissions (Figure 1). Even as hospitalization rates from all causes in HD patients have continued to decline, the fall in NVA infection-related admissions has been less than for CVD. Worse, the high rate of death or readmissions within 30 days of infection-related hospital discharges persists, exceeding 35%, or about 1 in 3 hospital admissions (Figure 2). Among patients initially discharged for CVD, a greater percentage of readmissions are also for CVD, whereas patients discharged from infections had a greater percentage of readmissions attributed to CVD and other causes (Figure 3). Plausibly, infections render the body more vulnerable to develop *de novo* or exacerbate comorbid diseases. In a study of HD patients, infections of sufficient severity to warrant hospitalization were proposed to trigger susceptibility toward CV events (2). Therefore, with such a great impact on morbidity and mortality of patients treated with maintenance HD, it is no coincidence that greater focus on infection control and prevention is required in outpatient HD facilities.

Trends in Vascular Access–Related Infections

Vascular access (VA)–related infections constitute the largest category of infections and represent the target of many infection prevention initiatives. A secular trend for declining overall hospitalization rate exists not only for HD but for the general and Centers for Medicare & Medicaid Services (CMS) Medicare populations, often ascribed to various initiatives designed to reduce unnecessary hospitalizations, greater use of chronic disease management programs, and the national shift toward outpatient treatment (3). It is

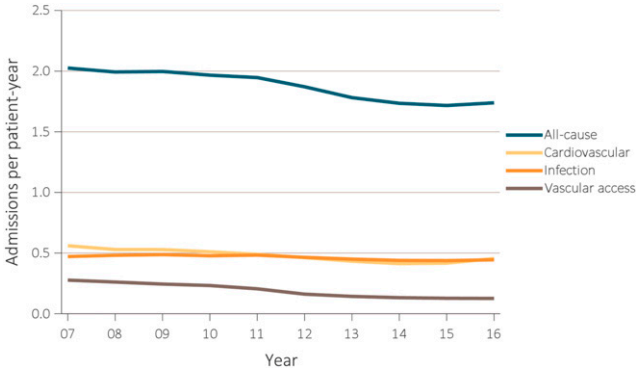

Figure 1. Adjusted all-cause and cause-specific hospitalization rates for ESRD patients, by treatment modality (HD), 2007-2016. All-cause hospitalization rates among adult HD patients decreased by approximately 15% from 2007 to 2016. Hospitalizations due to cardiovascular events and those for vascular access infection fell by approximately 19%% and approximately 55%%. Nonvascular access infection-related hospitalizations had minimal declines in comparison. Reprinted with permission from reference 1 (United States Renal Data System: 2018 USRDS annual data report: Epidemiology of kidney disease in the United States. Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. https://www.usrds.org/2018/download/v2_c03_VascAcc_18_usrds.pdf).

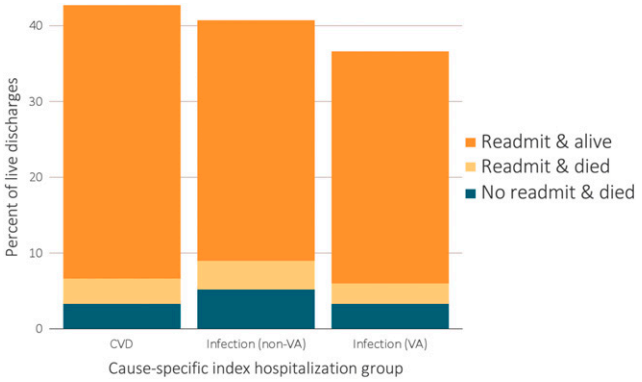

Figure 2. Proportion of hemodialysis patients discharged alive that either were readmitted or died within 30 days of discharge, by cause of index hospitalization, 2016. Death and 30-day readmission outcomes for the 3 most commonly identified causes of index hospitalization: CVD, non-vascular access infections and vascular access-related infections. Readmission rates are highest from CVD. Cumulative deaths within 30 days post-discharge (blue) or after readmission (yellow) are more frequent after infection-related discharges (middle bar). Reprinted with permission from reference 1 (United States Renal Data System: 2018 USRDS annual data report: Epidemiology of kidney disease in the United States. Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. https://www.usrds.org/2018/download/v2_c03_VascAcc_18_usrds.pdf).

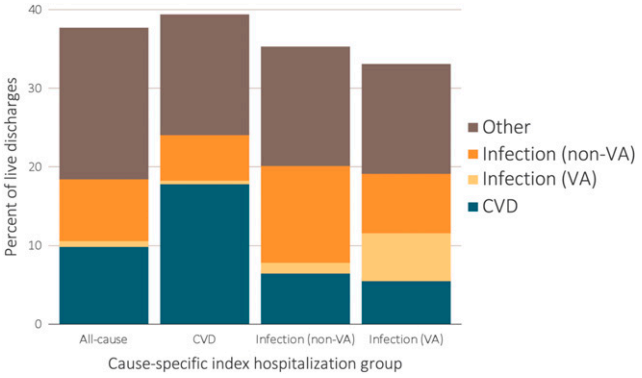

Figure 3. Proportion of hemodialysis patients with cause-specific readmissions within 30 days of discharge, by cause of index hospitalization, 2016. Cause-specific readmission rates indicate lower rates of same-diagnosis readmissions for the latter two of three commonly identified diagnostic categories: CVD, non-vascular access infections and vascular access-related infections. Reprinted with permission from reference 1 (United States Renal Data System: 2018 USRDS annual data report: Epidemiology of kidney disease in the United States. Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. https://www.usrds.org/2018/download/v2_c03_VascAcc_18_usrds.pdf).

tempting to attribute the decline in VA infection-related hospitalizations (Figure 1) solely to the national trend of decreasing hospital admissions. However, it is impossible to ignore the impact of efforts to increase the use of arteriovenous fistulas (AVFs) and decrease the use of central venous catheters (CVCs) over the past two decades. In 1997, the National Kidney Foundation's technical expert panel first published its recommendation that endorsed the native AVF as the preferred choice for vascular access in HD (4).

By 2003, efforts were under way to form a coalition to increase AVFs, later becoming a CMS "Breakthrough Initiative," christened as the "Fistula First" program for tracking rates of AVF use for maintenance HD patients at the outpatient HD facility level (5). The program then evolved to invoke a "Catheter Last" component, especially with the recognition that CVCs posed the highest risk for infections (6). The combined initiative to increase AVFs and decrease CVCs has been incorporated into the ESRD Quality Incentive Program (QIP). The QIP, first implemented in 2011, represents an integral component of the expanded Medicare prospective payment system. (7). The prevalence rate of AVFs in HD patients increased and the proportion with CVCs declined in facilities over time (Figure 4). This decline stems from converting CVCs to AVFs or arteriovenous grafts (AVGs) once patients are admitted to the outpatient dialysis facility as the care team focused efforts to meet QIP goals (Figure 5).

The apparent success of the VA initiative to decrease the prevalence of CVCs for HD patients likely contributed to the decline in hospitalizations due to VA-related infection, in combination with the shift from inpatient to outpatient observation status for acute conditions and an increased emphasis on using home health and home antibiotic services. However, two additional observations temper the decline in CVC prevalence. First, it is important to acknowledge the contribution of competing risk from other outcomes, particularly death, which occurs more frequently in sicker patients, who are more likely to die with a CVC (8) (Figure 6). Second, although the prevalent rates of CVCs declined, the incident rate of new patients initiating maintenance HD with CVCs remained at nearly 80% (Figure 7).

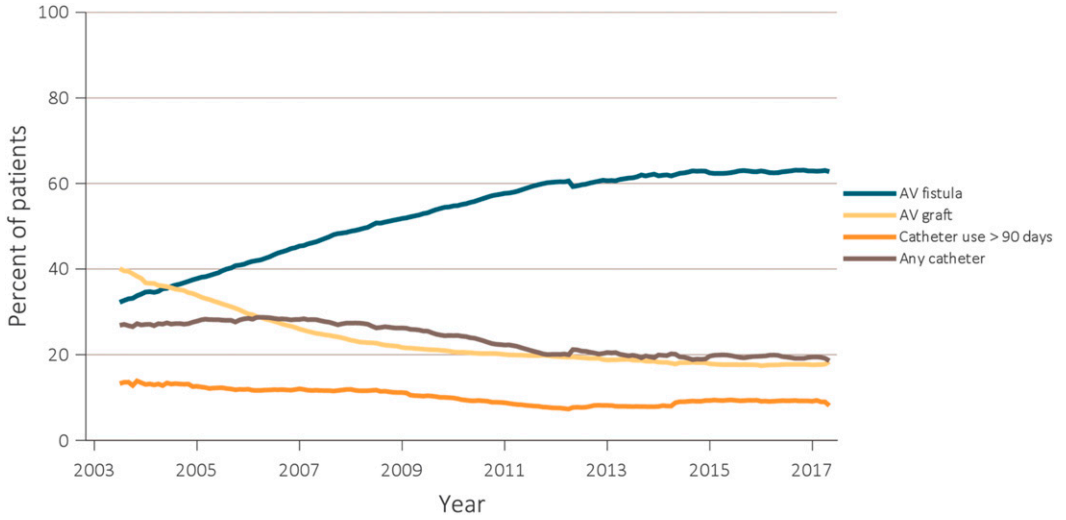

Figure 4. Trends in vascular access type use among ESRD prevalent patients, 2003-2017. The prevalent HD vascular access has shown an increase in AVFs with a decline in both AVG and CVC use over time. There appeared to be minimal change (if not a slight increase recently) in the prevalence rate of CVCs maintained in HD patients for μ90 days. Reprinted with permission from reference 1 (United States Renal Data System: 2018 USRDS annual data report: Epidemiology of kidney disease in the United States. Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. https://www.usrds.org/2018/download/v2_c03_VascAcc_18_usrds.pdf).

Therefore, greater focus is required to prepare patients with chronic kidney disease (CKD) before dialysis initiation, so that patients who opt for HD may avoid starting with a CVC altogether. This can be attained with an integrated care model that includes not just patients with CKD stage 5 (*i.e.*, eGFRs <15 ml/min per 1.73 m^2), but even earlier in high-risk stage 3 CKD (eGFRs between 30 and <60 ml/min with proteinuria), or, at the very least by stage 4 CKD, at eGFRs between 15 and <30 ml/min per 1.73 m^2

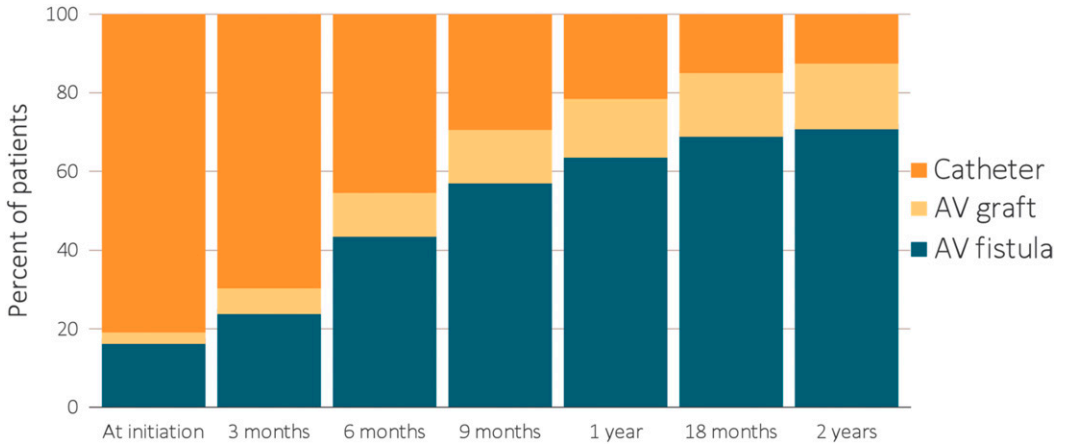

Figure 5. Change in type of vascular access during the first year of dialysis among patients starting ESRD via hemodialysis in 2013 quarterly: (a) type of vascular access in use (cross-sectional) ESRD Medical Evidence form (CMS 2728) and CROWNWeb, 2013-2017 The dialysis facility care team became more adept at converting vascular access away from central venous catheters primarily toward fistulas such that AV fistula prevalence increased to 64% by the end of one year on HD, and to 71% by the end of two years. The CVC rate dropped to 21% at one year,12% at 2 years. Reprinted with permission from reference 1 (United States Renal Data System: 2018 USRDS annual data report: Epidemiology of kidney disease in the United States. Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. https://www.usrds.org/2018/download/v2_c03_VascAcc_18_usrds.pdf).

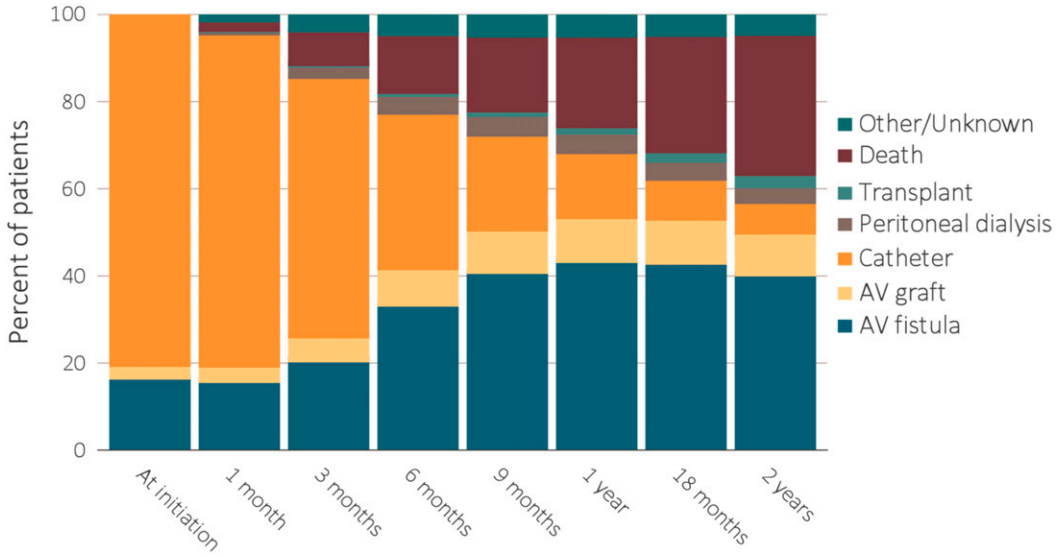

Figure 6. Change in type of vascular access during the first year of dialysis among patients starting ESRD via hemodialysis in 2013 quarterly: (b) longitudinal changes in vascular access use and other outcomes, ESRD Medical Evidence form (CMS 2728) and CROWNWeb, 2013-2017. Tracking the overall patient outcomes show that attrition of active prevalent HD patients (lower denominator) largely as a function of death, helps increase the prevalent rate of AVF/AVG, and, conversely, decreases the prevalent CVC rate shown in Figure 5. Reprinted with permission from reference 1 (United States Renal Data System: 2018 USRDS annual data report: Epidemiology of kidney disease in the United States. Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. https://www.usrds.org/2018/download/v2_c03_VascAcc_18_usrds.pdf).

(9). The principles for such a model have been deliberated by the Accountable Care Organization task force from the American Society of Nephrology (ASN). Despite an absence of Medicare funding, this model has been piloted by a United States nonprofit dialysis provider (10,11). Plans for these integrated care models are still under active discussion at multiple levels by professional societies, providers, policy makers, and regulators. That being the case, the risk of VA-related infection and attendant complications is a clear and present danger and must be addressed in parallel to initiatives that minimize CVC exposure.

Treating Vascular Access–Related Infections as Healthcare-Associated Infections

The Department of Health and Human Services (HHS) defines healthcare-associated infections (HAIs) as infections people acquire while receiving healthcare for another condition (12). Central line–associated bloodstream infections (BSIs) are a major category of recognized HAIs. The contribution of HD VA-related infections, primarily attributed to CVCs, was elevated to national prominence when the CDC estimated a national occurrence of approximately 37,000 episodes in 2008 alone (13). It was no surprise that when the DHHS convened a committee of scientists, public health professionals, and program officials from multiple agencies, including the CDC, CMS, and the Agency for Healthcare Research and Quality (AHRQ) to formulate the National Action Plan to Prevent Health Care Associated Infections. This roadmap for prevention of HAIs has, in its second phase, a chapter devoted to promotion of infection control practices in ESRD facilities (12). In addition to prevention of VA infections and other intravascular infections, the roadmap included modules to deal with bloodborne pathogen transmission (*e.g.*, hepatitis B and C viruses) and vaccinations for influenza and pneumococcal disease.

CMS has collaborated with the CDC in promoting the National Healthcare Safety Network (NHSN) as the platform for HAI reporting for the ESRD Quality Incentive Program (14). The NHSN Dialysis Event Module collects data on three types of dialysis events: positive blood cultures, IV antimicrobial therapy initiation, and pus or increased redness or swelling at the VA site. Facilities are expected to report all positive blood cultures from specimens collected from outpatients or collected within one calendar day

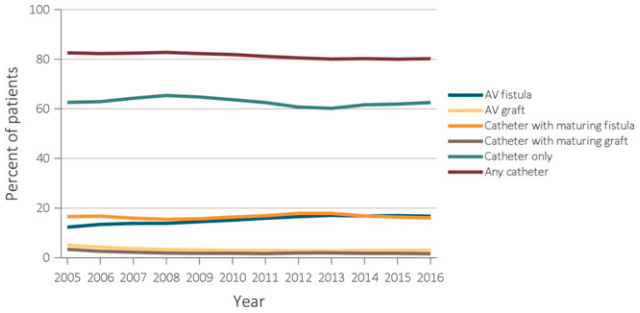

Figure 7. Vascular access use at hemodialysis initiation, from the ESRD Medical Evidence form (CMS 2728), 2005-2016. The vascular access used upon initiation of dialysis indicates that overall, approximately 80% of patients still start HD with a CVC (*i.e.*, any catheter). The policies enacted to help decrease CVCs and improve AVF rates apply only to patients who are already on dialysis because they are linked to the ESRD payment bundle. Reprinted with permission from reference 1 (United States Renal Data System: 2018 USRDS annual data report: Epidemiology of kidney disease in the United States. Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. https://www.usrds.org/2018/download/v2_c03_VascAcc_18_usrds.pdf).

after a hospital admission, regardless of whether a true infection is suspected or considered HD-related. Information on patient VA type is also submitted, and facilities must also indicate the suspected source of the infection (*i.e.*, VA, a non-VA source, contamination, or uncertain).

The CDC calculates an annual standardized infection ratio (SIR) of BSIs reported from each facility. The SIR compares the number of BSIs that a facility reported to the number of BSIs predicted for that facility based on nationally aggregated data. The data are summarized as a single number that facilitates the use of SIR for evaluation purposes. (Information on the NHSN Dialysis Event Surveillance BSI SIR Measure can be found at https://www.cdc.gov/nhsn/pdfs/dialysis/understanding-the-de-bsi-sir.pdf.) The BSI SIR is used to compare BSI rates across facilities and is a quality measure endorsed by the National Quality Forum. These data are used by CMS to determine incentive payments in the ESRD QIP (15). An important caveat is that this process relies on complete and uniform data collection, enabling data comparisons across similar and diverse facilities over time. The system breaks down when data collection is incomplete and/or is non-uniform.

The Dialysis Event Module uses strict definitions for each variable collected in the surveillance system. Consequently, surveillance definitions occasionally differ from clinical definitions. Whereas the clinical setting is dynamic and often relies on an individual to use training and experience to interpret information and act, surveillance requires uniform interpretation and reporting, regardless of an individual's clinical training and experience. Surveillance definitions are designed so they can be applied to information available in a patient's medical record without requiring additional review by a clinician while minimizing requirements for individual interpretation. Therefore, there may be instances whereby internal quality assessment and performance improvement (QAPI) initiatives that track BSIs within dialysis facilities may highlight different clinically relevant infection rates than those reported by NHSN. Furthermore, these differences often color facility staff reception toward NHSN data, especially when positive blood cultures are counted yet deemed clinically unimportant (*i.e.*, contaminant growth).

A more positive approach for staff who note this discrepancy would be to work toward eliminating contaminant growth by examining processes ensuring aseptic conditions during sample collections for blood culture. Another example of potential discrepancy between NHSN reports and real-world clinical findings may relate to positive blood cultures assigned to VA even when a local source of infection is identified clinically. Clearly, these differences should be taken into consideration when using NHSN data in parallel to internal data collection for QAPI. Similar caveats apply to the use of QIP by CMS. There is no standardized national policy on the indications and process for drawing blood for cultures despite recommendations from key opinion leaders to encourage physicians and staff to be more rigorous (16). CMS has included a reporting measure to track monthly reporting of facility blood culture results into the NHSN dialysis event module (15). Although imperfect, this measure is designed to incentivize complete reporting of data, in parallel with a few annual facility audits.

The Convergence of Policy and Practice: Preventable Infections Are a Matter of Patient Safety

Patients expect that treatments at their outpatient HD facility were designed to maintain if not improve

their health status. The responsibility of the healthcare team is an extension of a key component of the Hippocratic oath, "Primum non nocere"—from the Latin, "First, do no harm." Classified as an HAI, preventable infections in HD patients indicate a role for the healthcare system to avoid harm posed by these preventable infections. Hence, DHHS, CMS, CDC, AHRQ, and other professional and provider organizations, including the ASN, have recognized infection prevention in the HD facility as a matter of patient safety. In 2016, the CDC began the "Making Dialysis Safer Coalition" in response to an escalating infection rate among HD patients (17).

Beginning with 13 initial partners, the coalition has expanded to more than 39 partners. The ASN, a major partner of the Coalition, contracted with the CDC to use ASN's interactions, public policy initiatives, and educational activities in the broader nephrology community to accelerate the creation of a culture of empowerment among nephrologists to reduce infection rates in HD patients. The mission statement of this effort, entitled "Nephrologists Transforming Dialysis Safety" (NTDS), is "to enhance the quality of life for people with kidney failure by engaging nephrologists as team leaders in transformational change that continually improves the safety of life-sustaining dialysis" (18).

Nephrologists are at the forefront of taking leadership roles in preventing infections, as attending physicians for individual patients and Medical Directors of outpatient HD facilities, with additional management and population healthcare responsibilities. This issue of *NephSAP* along with resources identified throughout the syllabus is part of the ongoing commitment of ASN and CDC, under the umbrella of NTDS, to provide educational support to practicing nephrologists, administrators, and clinical fellows/trainees. Succeeding sections will provide information regarding leadership and a systems approach to preventing infections in the HD unit, a walk-through of general and specific recommendations that address potential areas for establishing best practices for infection prevention, and outward-looking approaches that help meet the need for future challenges and emergency preparedness.

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Systems Approach in Implementation of the National Safety Strategy

Understanding Systems Thinking and Applicability to Dialysis

As a special issue of NephSAP that addresses infection prevention in HD units, this issue encompasses basic concepts and principles as well as specifics on the latest developments in the field. In this section, we explore the roles and responsibilities of the care team, facility governance, care management, regulatory requirements, and culture of safety (or lack thereof) for the outpatient HD facility. We illustrate how the nephrologist, individually and as Medical Director, can use a systems approach to exert leadership that strives for an infection-free and safe treatment environment.

A system is an interdependent group of items, people, or processes with a common purpose. One can therefore imagine the outpatient HD unit as a system that could be a part of a larger system, such as a group of dialysis facilities within the umbrella of a dialysis provider organization. This organization may in turn represent a part of a CMS healthcare network run. Furthermore, the HD unit is also composed of smaller systems that encompass a dialysis shift, a dialysis pod, or individual patients whose microsystem includes support systems, transportation, dialysis, physicians, and other health-related and non–health-related services.

The key to systems thinking is to reflect and review the processes of care and to understand each step in a work flow environment, so that the steps with a higher potential for error may be recognized and remediated, improved, changed, or deleted. To illustrate, an error occurs because a round peg A is plugged into an inappropriate round hole B. The remedy of labeling a round hole as "only for peg A" and the other as "only for peg B" does not prevent the error if the label has faded or become detached or if a person hastily or hurriedly inserts peg A into the incorrect hole. By chance alone, this system process will still have an error rate over time. By contrast, if peg B and hole B were similarly altered as square, the new system would disallow confusion between pegs and holes; neither one fits the other. Thus, in this alternative process for another system, the human error factor was totally eliminated.

A real-life example deals with dialyzer reuse processing, in which a dual cross-checking procedure prevents dialyzer mislabeling with an incorrect patient name. However, it does not prevent the wrong dialyzer going to a patient when an error occurs much earlier in the complex reprocessing procedure (1) (*i.e.*, when the labeling of the reused dialyzer itself was erroneous). One way for the system to prevent mishandling, mislabeling, and ultimately placement of the wrong reused dialyzer for a patient is to abandon the complex reuse procedure and use new factory-sterilized dialyzers for each treatment (2). Of note, the reprocessing procedure for dialyzer reuse has been implicated as an infection risk in at least a few outbreaks in HD facilities, including one recently (3). However, any decision that impacts the facility's operations entails review at multiple levels, with considerations for clinical, environmental, human resources, economics, and contractual obligations that the HD facility may have. There is no single answer for all situations. Such decisions are primarily undertaken by the leadership of the outpatient HD facility, the governing body.

The Nephrologist's Role in the Outpatient Hemodialysis Facility "System"

In outpatient HD facilities, nephrologists can play two distinct roles: attending physician and Medical Director. These roles are clearly delineated by the Conditions for Coverage (CfC) and the accompanying Interpretive Guidance (IG) that provides details regarding CfC implementation (4,5). As attending physicians, nephrologists are responsible for the care of their individual patients within the facility. They are expected to follow acceptable practice guidelines and policies and procedures of the facility. By contrast, the Medical Director is responsible for the outcomes in the entire population of patients within the dialysis facility. Wheres the Medical Director may also play the role of attending physician for individual patients, directorship must be recognized as being distinct from specific patient care activities. The job entails being chair of the Quality Assurance and Performance Improvement team, clinical leader of the facility's governing body, and accountable official tasked with maintaining the safety of the dialysis clinic patient population and staff (4). The distinctions between these roles are enumerated in Table 1.

The CfC requires the attending physician to participate in the Interdisciplinary Team (IDT). The IDT is a multidisciplinary team that includes nurses, social workers, patient care technicians (important team members but not officially required by the CMS definition), facility administration, and an attending physician who should act as the chairperson of the IDT. Patients are expected to be

Table 1. Distinct roles of attending physician and Medical Director within an outpatient hemodialysis facility that a practicing nephrologist could assume: comparison of roles and responsibilities

Attending Physician	Medical Director
Responsible for care of assigned patients	Responsible for all aspects of care delivery
Follow medical staff bylaws	Assume leadership role of facility
Compliance with quality programs	Chair of QAPI
Responsible to Medical Director queries	Responsible for population of patients in reference to quality program
Participate in interdisciplinary team and act as a chairperson	Interact with medical staff
Complete POC and CIAs	

Original work, courtesy of Dr. Edward R. Jones, Delaware Valley Nephrology (retired), (Philadelphia, PA), and Dr. Bradley A. Warady, Children's Mercy Hospitals & Clinics (Kansas City, MO). CIA, comprehensive interdisciplinary assessment; POC, plan of care; QAPI, quality assurance and performance improvement.

invited to IDTs to review their individualized plans of care (POCs). The IDT is expected to complete a plan of care and a Comprehensive Interdisciplinary Assessment (CIA) at 30 days, 90 days, and 1 year after dialysis initiation. Patients whose conditions are deemed unstable are reviewed monthly. The IDT monitors all aspects of care, including infection prevention and infection-related complications. A Medical Director participates in the IDT if she/he has oversight of individual patients in the capacity of attending physician, not as the IDT chairperson.

However, the Medical Director must assure that IDT meetings are held as scheduled and that responsible attending physicians are participating in their IDTs and completing required evaluations. The Medical Director is expected to meet with attending physicians about performances that are not achieving established metrics of care. In turn, the attending physician is expected to abide by all policies of the facility as approved by the Governing Body and to conform to delivering quality care.

The CfC established the QAPI program as the vehicle for oversight of the delivery of "High Quality and Safe Care" (7). The QAPI team (Table 2) is a multidisciplinary team that includes, in addition to nephrologists, nurses, dialysis technicians, social workers, and project leaders (*e.g.*, infection prevention nurse, vascular access manager, patient care technicians). In the setting of dialysis provider organizations, the corporate operations team may have administrative and/or quality oversight/support for the facility (*e.g.*, area operations director, area manager, regional quality manager). Note that the Medical Director's role as QAPI program leader cannot be delegated to the clinical manager.

The QAPI team meets monthly and is responsible for all aspects of care delivery in the facility, including facility issues and processes of care. The focus of oversight includes reviewing all quality metrics to identify variations in a variety of quality outcomes, including those pertaining to infection. The promotion of quality care and patient safety by the Medical Director and the QAPI team includes ensuring a philosophy of zero tolerance for infections. Monitoring of BSIs, reporting to the NHSN, and reviewing blood-borne pathogens (*e.g.*, hepatitis B and C) and immunizations must be conducted and addressed by the QAPI team under the direction of the Medical Director.

The Conditions for Coverage mandate that the nephrologist Medical Director is responsible for ensuring that high-quality and safe care is delivered in the facility. The Medical Director leads the Quality Assessment and Performance Improvement Committee, through which the nephrologist identifies best practices and deficiencies in safe and high-quality care. The Quality Assessment and Performance Improvement Committee should use continuous quality improvement activities (*e.g.*, Plan-Do-Study-Act cycle) to conduct root cause analyses and generate action plans to address deficiencies.

The Role of Team Members in the Outpatient Hemodialysis Facility System

Reducing infections in dialysis is not an individual responsibility. This goal requires engagement by all. Any individual violating any component of an infection control practice compromises the attempts of others to eliminate infections in an environment that is

Table 2. Members and role of quality assessment and performance improvement team in outpatient hemodialysis facility

Committee Members	Role: All Members
Medical Director (chairperson) Director of operations (CEO/area manager/OM) • Clinic manager, social worker, dietician Technical representatives Optional: RVP, RQM, CCHT, RHTM, education, anemia nurse, vascular access manager, patients, staff physicians	Present data Present plan for change Present results of previous process changes

Original work, courtesy of Dr. Edward R. Jones, Delaware Valley Nephrology (retired), (Philadelphia, PA), and Dr. Bradley A. Warady, Children's Mercy Hospitals & Clinics (Kansas City, MO). CCHT, certified clinical hemodialysis technician; CEO, chief executive officer; OM, operations manager; RHTM, regional hemodialysis technical manager; RQM, regional quality manager; RVP, regional vice president.

susceptible to cross-contamination. Department of Health surveyors may cite individuals and the entire facility with violation tags (V625 and V626) for failure to adhere to good infection prevention practices (5). Infection control responsibility is not restricted to the domain of the physician-in-charge. This responsibility includes an entire team composed of dialysis nurses, technicians, social workers, renal dietitians, patients, and visitors. Nurses and dialysis technicians constitute the largest population in the facility to perform the procedurally intensive dialysis treatment. However, renal social workers and dietitians play an integral role in not only managing clinical aspects of illness but also fostering communication and clarity of purpose to the achievement of unified goals. Patients and visitors also constitute an often-neglected sector of team members who contribute to outcomes and are ultimately the beneficiaries of high-quality and safe clinical care.

The role of the nephrology nurse as described by the American Nephrology Nurses Association (ANNA) encompasses these responsibilities: "The nephrology nurse functions as a coordinator of patient care collaborating with other care providers and health team members to provide required care as effectively as possible. The nephrology nurse may also function as a nurse manager to assure the delivery of appropriate care. The nephrology nurse actively participates in professional role development activities including continuing education, quality assessment and improvement, and the review and clinical application of research findings. The nephrology nurse develops ethically sound practice and confronts ethical challenges through application of the Nephrology Nursing Standards of Practice and Standards of Care" (6). Performing effective infection control practice, displaying knowledge and adherence to policies and procedures, and encouraging and mentoring others are key to ensuring that all are engaged in the process of infection control. It is not uncommon for the nurse/clinic manager to become the operational leader, a second-in-command individual who facilitates communication, expects accountability, and directs implementation of the Medical Director's plans to achieve clinical quality, safety, and administrative goals in the facility.

Patient care technicians are ideally recognized as members of the interdisciplinary team with the greatest day-to-day contact with the dialysis patient. Technicians set up machines, initiate dialysis, monitor and discontinue treatments, and conduct machine cleaning and disinfection. The minimum educational qualification as cited in the CMS ESRD conditions for coverage is a high school diploma or the equivalent (4). Training of technicians is typically provided as an on-the job process or with a limited program within an academic institution or technical training school. CMS requires training program approval by the Medical Director and Governing Body. The program is under the direction of a registered nurse, is focused on the operation of kidney dialysis equipment and machines, and provides direct patient care and communication and interpersonal skills, including patient sensitivity training and care of difficult patients (7). Certification must be achieved within 18 months of being hired at a facility. Given this background, the minimum qualifications and lack of a standardized academic, formal training program, technician knowledge, and practice level for infection prevention and control may initially be rudimentary.

With experience and appropriate role modeling and guidance, technicians can be and have been instrumental in contributing to the success of an infection control program. At a minimum, they are expected to become knowledgeable about the principles and practice of infection prevention; implement

the policies and procedures, including those related to infection prevention and control; and serve as the "eyes and ears" of physicians, nurses, and clinical staff who do not have the same contact frequency with patients as technicians do. The close relationship between the technician and the maintenance HD patient is a product of the amount of time they spend interacting with each other. The bond of trust and familiarity that develops can effectively foster education of patients to different aspects of dialysis, including infection control.

The interactions of social workers with HD patients are primarily of interviews and discussions. Social workers are essential to the well-being of patients and their adjustment to dialysis. Their role is to support the psychosocial needs of the renal patient and to discuss and assess issues such as family and other support systems, financial and insurance information, emotional health, physical (dis)abilities, and legal documentations such as advanced directives as examples.

Renal dietitians monitor, educate, and communicate to the interdisciplinary team the nutritional and dietary status of patients. The social worker and dietitian ideally will play a role in infection prevention and control. This role is summarized as three principal areas: 1) knowledge and practice of infection prevention and control policies and procedures so that these individuals do not become vehicles for spreading infections, *e.g.*, performing hand hygiene and observing necessary precautions, 2) using interview sessions to help educate the patient regarding principles of infection prevention, and 3) identifying aspects of patient concerns, support systems, and lifestyles that may be enhanced or modified to support initiatives aimed at infection prevention and control within the facility. Any findings should be communicated with the rest of the IDT and addressed as needed.

Regarding patients and visitors, the range of familiarity with infection prevention and control will be diverse. Their activities at home and when they report to the facility can have an impact in the success of an infection prevention and control program. Adherence with facility infection prevention policies, engagement in discussions, participation in infection control programs, and education involving the reporting of signs and symptoms of an infection are areas that the care team can develop to harness the contributions of patients. Patient and family engagement is a hot topic in healthcare and one that is very important in the dialysis facility setting, particularly in infection control and prevention, and this issue will be discussed later.

The level of involvement with infection control practices can vary with each discipline, including patients and visitors. Reducing infection in dialysis requires engagement of each individual team member and familiarity with the proper practice of infection control and prevention.

Leading the Infection Prevention QAPI Process in the Outpatient Hemodialysis Facility

When problem solving, nephrology physicians are trained to create a problem list, enumerate causes of the problems, develop and implement a care plan, and collect follow-up data. These processes are identical to those used in the QAPI program that uses the principles of total quality management adapted from the manufacturing industry into healthcare (8): the Plan-Do-Check-Act method using root cause analysis (Table 3). This systematic approach is useful to handle the complicated issues arising in the dialysis unit. Understanding the organizational impact of the nephrologist's leadership can greatly aid efforts to improve patient outcomes. The dialysis staff look to the Medical Director as the leader of the QAPI program who sets the direction and goals for improving clinical care in the facility. Finally, Medical Directors are empowered not only by leadership of purpose but by regulation, as specified by the CfC (4).

In surveys of dialysis facilities performed by state agencies (ideally every 3 years but in some states less often), citations are rendered when outcomes are not achieved or when obvious patient safety issues are present. The Medical Director's role that oversees the entire facility is monitored by surveyors. An increasing number of citations have named Medical Directors in their oversight role. The leadership of the Medical Director in these instances can often result in either temporary or sustained improvement, as illustrated in the example below.

Consider the case of a facility with a problem of poor adherence to the CDC guidelines for BSI prevention that is cited by a state surveyor. An immediate

Table 3. Plan-Do-Check-Act cycle adapted to quality assessment and performance improvement

Plan	Do	Check	Act
What is the variation? Use of tools to collect and evaluate	Collect data Tabulate and/or graph data; flow charts, run charts	Examine results and reevaluate Use of Fishbone diagram, Pareto charts, histogram, etc.	If met goals, adopt and consider expanding to other problems; if not, recycle and go to new plan
Brainstorming	Calculate percentages	Is the process working? Reevaluate root cause	
Determine root cause Make a plan for change Simple and focused Designate personnel and resources Determine a timeline Feedback to QAPI	Document findings	Document progress	

Original work, courtesy of Dr. Edward R. Jones, Delaware Valley Nephrology (retired), (Philadelphia, PA), and Dr. Bradley A. Warady, Children's Mercy Hospitals & Clinics (Kansas City, MO). QAPI, quality assessment and performance improvement.

plan of correction is required, and the symptomatic solution is to focus on staff retraining and disciplinary action that satisfies the plan of correction and results in short-term improvements in compliance. However, the disciplinary actions by the state against the facility and the facility against employees have the unintended consequence of creating fear of punishment. This results in staff being afraid to report errors or policy breaches owing to fear of retribution. Once the acute crisis has passed, the attention to detail of staff may be short-lived, particularly if no systemic process changes were made. Complacency develops, and when complacency is combined with underreporting due to fear of reprisal, it is no surprise that dialysis infection control problems eventually resurface.

True leadership involves detail and attention to, and committed and persistent involvement with, the frontline issues workers face. Leaders must understand the established norms and "hidden culture" that often guide behavior (9). The Medical Director must dedicate time in the facility unrelated to individual patient care but focused on an understanding of care processes and staff culture. The Director must observe clinical practice and activities (*e.g.*, hand hygiene, use of personal protection equipment, touching machines without gloves) and address well-recognized risk factors with physician colleagues and staff to achieve the desired patient and facility outcomes as they relate to infection prevention. Thus, it is feasible for Medical Directors to determine behaviors and motivations of workers to determine sustainable solutions that address fundamental issues. Successful solution implementation requires time and effort, which may require multiple PDCA cycles and include consultations with, and/or assistance from, experts. CMS has opined that Medical Directors should spend 25% of their overall professional time conducting Medical Directorship activities.

Nephrologists may not have been trained specifically in leadership, although the intellect and breadth of knowledge to learn and master this role is present. As the Medical Director, it is essential for the nephrologist to dedicate time and effort to leadership. Four essential steps may allow for developing the culture that makes leadership successful. The first is to develop a sense of trust within the healthcare team. Second, one must appreciate intrinsic altruism as a motivation for members of the healthcare team to choose this career path. In the setting of a crisis, whereas it is essential to ensure that patients are not in danger, it is imperative to determine systemic issues that facilitated the presence of unsafe conditions. A focus on individual(s) to blame will not accomplish this. Third, one must appreciate that "culture trumps strategy" and that culture represents a measure of the degree to which the care team share values, goals, and sense of purpose to perform work and arrive at desired outcomes. Therefore, the Medical Director must articulate the values, goals, rationale, and common purpose that the healthcare team shares when defining the direction of an initiative.

Finally, the Medical Director must be able to clearly share the vision even when details are not yet

determined, because the healthcare team may contribute details needed to make the vision a reality. However, the Medical Director must not be afraid to seek guidance, knowledge, and assistance, whether from peers, dialysis organizations, professional organizations, or government organizations, to hone the vision, minimize confusion, and lead teams to appropriate goals. Effective leadership influences individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine a culture of safety (10), particularly in an environment of infection prevention and control.

Returning to the case of a facility with poor adherence to CDC guidelines for BSI prevention (as cited by a state surveyor), the initial solution discussed above was a symptomatic solution, not a fundamental solution, and would potentially produce unintended consequences and future problems. A fundamental solution is creating a more effective culture of safety to promote infection prevention and control. Adopting a systems-based philosophy fits the QAPI process perfectly, facilitates greater introspection and dialogue regarding root causes of infections, and encourages facility-wide cooperation. Better leadership and participation in QAPI and the use of systems thinking are tremendous opportunities for improvement for Medical Directors and attending nephrologists alike (Figure 8) (11). Attending nephrologists can subvert Medical Directors and QAPI effectiveness through intended or unintended behaviors such as refusing to follow protocols, tardy responses to facility or Medical Director inquiries, or conflicts with dialysis staff (12). In such circumstances, attending physicians should consider themselves situational leaders and part of the bigger system, ignoring personality conflicts or practicing politics when contributions to infection control and prevention processes are needed.

Building a Culture of Safety—Foundational for the Success of Human Systems

Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures (13). The Agency for Healthcare Research and Quality (AHRQ) defines safety culture as encompassing these elements: 1) acknowledgment of the high-risk nature of an organization's activities and the determination to achieve consistently safe operations; 2) a blame-free environment where individuals are able to report errors or near-misses without fear of reprimand or punishment; 3) encouragement of collaboration across ranks and disciplines to seek solutions to patient safety problems; and 4) organizational commitment of resources to address safety concerns (9). The elements of a safety culture as applied to outpatient hemodialysis facilities are enumerated in Table 4 (14).

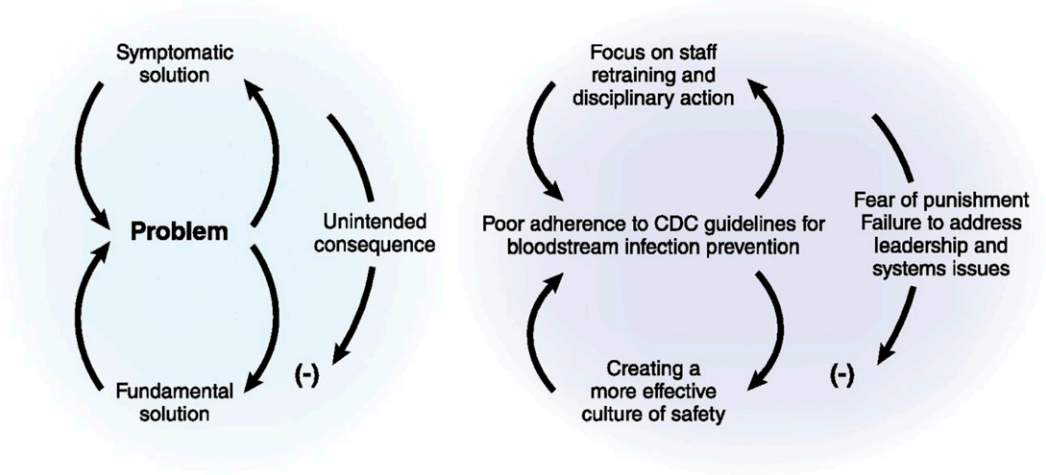

Figure 8. Example of an unintended consequence of a short-term or symptomatic solution to an infection control problem. CDC, Centers for Disease Control and Prevention. Modified with permission from reference 11 (Wong LW: Systems thinking and leadership: how nephrologists can transform dialysis safety to prevent infections. *CJASN* 13: 655-662, 2018).

Table 4. Principles of a culture of safety

- Dialysis is a high-risk procedure.
- Safety is maximized by understanding and adhering to policies and procedures.
- Errors are usually system failures, not individual failures.
- Time and technology resources should be committed to correct errors.
- A safety environment is not inherently error-free: To err is human.
- Reporting in a blame-free and retaliation-free environment leads to improvement.
- Use root-cause analysis and peer-review to solve problems.

Original work, Courtesy of Dr. Renee Garrick, Westchester Medical Center (Valhalla, New York).

In practice, this describes a system in which healthcare professionals are held accountable for unprofessional conduct, yet are not punished for human mistakes; errors are identified and mitigated before harm occurs; and systems are in place to enable staff to learn from errors and near-misses and prevent recurrences. The accountability aspect relies on identification of human error (*e.g.*, slips) versus at-risk behavior (*e.g.*, taking shortcuts), versus reckless behavior (*e.g.*, ignoring required safety steps), precepts consistent with a "just" culture (9). This more nuanced approach further focuses on identifying and addressing systems issues that lead individuals to engage in unsafe behaviors while maintaining individual accountability by establishing zero tolerance for reckless behavior. In addition to trust and a just culture, positive behaviors that must be exhibited by the Medical Director and reinforced for each member of the healthcare team include transparency, effective teamwork, strong communications, respect, and timely feedback.

Operationally, components that contribute to effective teamwork include precise and accurate communication, coordination that maximizes expertise of different team members, recognition of and respect for the contributions of team members, team-based learning and skills assessment, and feedback to ensure that each team member understands the vision, context, and goals for patient safety (15). Examples of team communication enhancement strategies may include 1) briefings that "plan forward" with all caregivers to recognize special safety concerns of the day, such as a change in patient status or requirement for a new medication; 2) debriefings at the end of the time of care that can review situations for learning together; and 3) huddles that may be used to quickly call the team together to review a specific situation to ensure shared understanding for best patient safety.

One way to engage the facility in the education of safety principles together is to participate in a common goal such as the 5-Diamond Safety Program (16). In 2008, the ESRD Network of New England (formerly Network 1) and the Mid-Atlantic Renal Coalition (now Quality Insights Renal Network 5), serving as ESRD contractors for the CMS, launched the 5-Diamond Patient Safety Program to help dialysis facilities increase awareness of, promote, and build a culture of patient safety. Now in its eleventh year, the program has become an automated, online, national educational resource, consisting of 18 modules ranging from topics like hand hygiene, influenza vaccination, and emergency preparedness that includes tools and resources required to implement each safety topic. Modules may be completed for recognition or viewed as a resource. For each module successfully completed during a program year, the facility earns one Diamond. Upon successful completion of five modules, including the mandatory "Culture of Safety" module, and a Program Review questionnaire completed by all facility staff including the Medical Director, the facility is recognized as a 5-Diamond Patient Safety Facility (17).

Finally, two factors are influential in changing safety culture. First, there must be a belief that engaging in the target behaviors will improve patient safety. Second, the team should have a favorable perception of patient safety-related behaviors exhibited by professional colleagues (18). Belief may be influenced by education and driven by data. Peer behavior, particularly of Medical Directors and nephrologists, is very influential to affect adherence and safety-oriented behaviors of the healthcare team. Effective infection prevention requires close attention to such adaptive changes when lapses in infection control practices are identified. The QAPI program is the structure through which both clinical and nonclinical knowledge

can be used to strengthen safety culture. This is accomplished by an ongoing scrutiny of data, use of root cause analysis of safety issues to define system issues, design of action plans to resolve problems, and, most importantly, the provision of communication about the action plan, its rationale, and everyone's role in and responsibilities to the action plan. Once changes are made, metrics should be monitored, with willingness to readjust the action plan if results are not satisfactory.

The team will take QAPI seriously if the Medical Director and the attending nephrologists lead by example. By extension, the same is true of infection control and prevention. Many determinants of safety culture are dependent on interprofessional relationships and other local circumstances; thus, changing safety culture occurs at a microsystem level (9). As a result, safety culture improvement often needs to emphasize incremental changes to providers' routine behaviors. Successful leadership by the Medical Director manifests when team members and patients exercise situational leadership by asking questions, communicate about risk and safety, speak out when risky behavior is observed, and are empowered to act without fear. Last, nephrologists, including Medical Directors, must adhere to principles of infection control and prevention and allow themselves to be reminded by other team members of their own missteps, however minor.

Belief in the efficacy of proposed changes among the facility's care providers is critical to a culture of safety. This belief can be positively influenced by education and data, both of which can be driven by leadership of the Medical Director and the nurse manager through the facility's Quality Assessment and Performance Improvement Program.

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Universal Infection Prevention Strategies Applied to Outpatient Hemodialysis Facilities

Standard Precautions: Hand Hygiene

The CDC recommends that healthcare personnel use Standard Precautions during patient care in all healthcare settings to prevent pathogen transmission (1). Standard Precautions include hand hygiene, use of

personal protective equipment (PPE), and respiratory hygiene/cough etiquette.

Hand hygiene is considered the single most important practice for reducing transmission of infectious agents in healthcare settings (2). The term "hand hygiene" includes the use of alcohol-based hand rubs (ABHRs) that do not require the use of water and handwashing with plain or antiseptic-containing soap and water. ABHRs have been shown to reduce bacteria and viruses on the hands of personnel more effectively than plain or antimicrobial soaps (2,3). ABHRs cause less skin irritation and dryness than soap and water handwashing, are more accessible, and require less time to use. Ease of access to proper handwashing sinks with available soap, warm water, and drying methods and ready access to ABHR dispensers is essential for hand hygiene compliance. Fingernails should be kept short and clean. Artificial fingernails or extenders that harbor bacteria and have been associated with several outbreaks should not be worn by anyone providing direct contact with patients, particularly those at high risk for infections.

Whereas studies in hospitals (none in freestanding hemodialysis centers) have shown that microorganisms can be transferred between the stethoscope and the patient, these have not been linked to infections (4–7). The preferred way of disinfection has not been determined, and disinfecting stethoscopes has not been demonstrated to decrease infection rates (8–10). Although this practice is not supported by evidence, it may be prudent to clean the stethoscope periodically with the same alcohol-based hand rub or chlorhexidine-based solution used for hand hygiene.

Both CDC and the World Health Organization (WHO) recommend the following:

1. Wash hands with soap and water when they are visibly dirty or visibly soiled with blood or other body fluids, and after using the toilet. The lathering process alone should be at least 20 seconds, and the entire procedure, including rinse, lasts about a minute or so.
2. Use an ABHR as the preferred means for routine hand antisepsis in all other clinical situations if hands are not visibly soiled. If an appropriate amount of hand rub is applied to the palm, and hands are rubbed together until they feel dry, this process should take >20 seconds. All surfaces of the hands and fingers should be covered when applying hand rub. Areas frequently missed include the thumbs and fingertips (11).
3. If exposure to potential spore-forming pathogens is strongly suspected or proved, including outbreaks of *Clostridioides difficile*, handwashing with soap and water is the preferred method of hand antisepsis. In its spore form *C difficile* is highly resistant to the bactericidal effects of alcohol.

A demonstration of steps for proper handwashing from the World Health Organization is available at http://www.who.int/gpsc/5may/How_To_HandWash_Poster.pdf.

Representative situations that occur in the outpatient HD unit that require careful attention to hand hygiene are listed in Table 5. Hand hygiene practices of HD personnel, including physicians, should be observed on a regular basis, and personnel should be given feedback regarding their performance. Additionally, patients should be instructed on the importance of hand hygiene, encouraged to wash their accesses before cannulation and after the treatment (*i.e.*, after hemostasis), and participate as part of a team to ensure infection control adherence in the unit. A hand hygiene Audit Tool for use in hemodialysis settings is available at the CDC website, https://www.cdc.gov/dialysis/PDFs/collaborative/Hemodialysis-Hand-Hygiene-Observations.pdf (12).

Standard Precautions: Personal Protective Equipment

As part of Standard Precautions, PPE falls under a category of "isolation precautions" (13), designed to prevent transmission by "isolating" infectious agents from contact transmission (not to be confused with isolation room policies per se). PPE refers to specialized clothing or equipment worn for protection against infectious materials. When selecting PPE, consider the type of anticipated exposure for the patient interaction, likely modes of pathogen transmission, and durability/appropriateness of the PPE for the task. During hemodialysis, potential exposure to blood and contaminated items is routinely anticipated. All PPE should be changed immediately if soiled by blood, body fluids, secretions, or excretions. Having PPE readily available is essential to increase compliance. In the dialysis setting, PPE should be dedicated for patients at increased risk for spreading pathogens to other patients. These patients include those with infected draining skin wounds whose drainage is not contained by dressings, fecal incontinence, or uncontrolled diarrhea (*e.g.*, *Clostridioides difficile*), and hepatitis B virus–positive patients.

Table 5. Situations that require hand hygiene procedures

Before touching a patient	Before entering patient station
	Before touching vascular access site
	Before adjusting or removing cannulation needles
Before aseptic procedures	Before cannulation or accessing catheter
	Before performing catheter site care
	Before preparing parenteral medication
After body fluid exposure risk	After exposure to any blood or body fluids
	After contact with other contaminated fluids (*e.g.*, spent dialysate)
	After handling used dialyzers, blood tubing, or prime buckets
	After performing wound care or dressing changes
After touching a patient	When leaving station
	After removing gloves
After touching patient surroundings	After touching dialysis machine
	After touching other items within dialysis station After using chairside computers for charting
	When leaving station
	After removing gloves

From reference 12 (Centers for Disease Control and Prevention: Hand hygiene audit tool. Available at https://www.cdc.gov/dialysis/PDFs/collaborative/Hemodialysis-Hand-Hygiene-Observations.pdf.

Types of PPE refer to specific implements that protect hands, skin/body, and face, as enumerated below:

1. Gloves
   - Purpose: Prevent contamination of healthcare personnel hands.
   - When wearing:
     - Always work from clean-to-dirty. This refers to touching clean body sites or surfaces before touching dirty or heavily contaminated areas.
     - Limit opportunities for touch contamination by keeping hands away from the face and avoiding touching or adjusting other PPE with contaminated gloves or touching environmental surfaces with contaminated gloves.
     - Change gloves as needed if torn or heavily soiled. Always change gloves and perform hand hygiene after each patient and before moving on to the next patient.
     - Extend gloves over the cuffs of the gown.

2. Gowns
   - Purpose: Protect healthcare personnel by preventing contamination of skin and clothing during procedures and patient-care activities during contact with blood, body fluids, secretions, or excretions as anticipated.
   - Facilities should have established protocols for discarding disposable gowns or laundering reusable gowns.

3. Face protection
   - Purpose: Protects healthcare personnel from contact with infectious material from patients' respiratory secretions and sprays of blood or body fluids.
   - Includes masks, goggles, face shields.
   - Masks protect the nose and mouth and should fully cover both to prevent fluid penetration.
   - Goggles should fit snugly over and around the eyes to provide protection.
     - Personal glasses do not provide optimal protection and should not be used as a substitute for goggles.
     - Face shields should cover the forehead, extend below the chin, and wrap around the side of the face to protect the face, nose, mouth, and eyes.

There is a CDC-recommended sequence for donning and doffing PPE designed to minimize contamination: available at https://www.cdc.gov/hai/pdfs/ppe/ppeposter148.pdf. The general use of PPE involves some general principles listed below:

1. Wear PPE during patient care when contact with blood or body fluids is anticipated
2. Wear gloves when anticipating contact with blood, body fluids, or other potentially infectious materials, mucous membranes, nonintact skin or potentially contaminated intact skin, or handling/touching visibly or potentially contaminated patient care equipment and environmental surfaces.

- Because exposure to blood and potentially contaminated items is routinely anticipated during hemodialysis, gloves are required whenever touching the patient 's equipment.

3. Wear gloves when cleaning the environment or medical equipment.
4. Remove gloves after contact with the patient and/or surrounding environment, including medical equipment. Do not wear the same pair of gloves for care of more than one patient.
5. Add face protection when performing procedures during which you can reasonably anticipate splashing of blood or other potentially infectious materials (*i.e.*, during initiation and termination of dialysis, cleaning of dialyzers, centrifugation of blood).
6. Prevent contamination of clothing and skin when removing PPE.

In the outpatient HD facility, patient care procedures may require use of PPE and, in some cases, multiple changes (*e.g.*, gloves are changed several times in the process of appropriately connecting/disconnecting a hemodialysis catheter per treatment or additional precautions when treating patients in the isolation room). Many providers may ask patient care staff to change into clean gloves when working on the treatment sheet. In some cases, not only are patient care staff required to don masks, but patients may be asked to wear them too (*e.g.*, the process of appropriately connecting/disconnecting a hemodialysis catheter). It is not unusual for patient care staff who are not vaccinated against influenza (*e.g.*, anaphylactic reaction or refused to be vaccinated) to be asked to wear masks in the dialysis facility during the influenza season. Patient care staff should avoid wearing their PPE outside the treatment areas such as in the lobby or break room. However, to facilitate this issue, there should be designated areas to discard PPE before leaving the treatment area — trash bins for disposable PPE and/or collection baskets for reusable gowns. If reusable gowns are used, the facility must have a sufficient supply of gowns to accommodate the size requirements of the staff and to have laundry procedures to ensure adequate turnover. Last, these rules should apply to all patient care staff who enter the treatment areas, including social workers, dietitians, and nephrologists.

Standard Precautions: Respiratory Hygiene/ Cough Etiquette

Implement respiratory hygiene and cough etiquette measures during cold and influenza season to all persons who enter the dialysis facility, including healthcare personnel, patients, and visitors. Also consider implementation during periods of increased respiratory infection activity in the community that may not coincide with cold and influenza season.

1. Hemodialysis units should educate personnel, patients, and visitors about measures to contain respiratory secretions to reduce the spread of respiratory pathogens such as influenza virus.
2. At unit entrances, post signs with instructions to patients and other persons with respiratory symptoms to cover their mouths/noses when coughing or sneezing, use disposable tissues, and perform hand hygiene after hands have been in contact with respiratory secretions.
3. Provide disposable tissues and no-touch receptacles for discarding tissues, and offer masks to coughing patients or other individuals with respiratory symptoms upon entry into the facility. Provide conveniently located dispensers of ABHR, and where sinks are available, provide supplies for handwashing.

These simple steps are available as visual cues that could be posted in the outpatient HD facility. They are downloadable from the CDC website: http://www.health.state.mn.us/divs/idepc/dtopics/infectioncontrol/cover/hcp/cycphceng.pdf)

Standard Precautions: Injection Safety

As defined by the World Health Organization, a safe injection does not harm the recipient, does not expose the provider to any avoidable risks, and does not result in waste that is dangerous for the community. Safe injection practices are applicable in all healthcare settings and are part of Standard Precautions. Injection safety includes practices intended to prevent transmission of infectious diseases between one patient and another, or between a patient and healthcare provider during preparation and administration of parenteral medications (13). Unsafe injection practices that have led to patient harm include the following: 1) use of a single syringe, with or without the same needle, to administer medication to multiple patients; 2) reinsertion of a used syringe, with or

without the same needle, into a medication vial or solution container (*e.g.*, saline bag) to obtain additional medication for a single patient and then using that vial or solution container for subsequent patients; and 3) preparation of medications in close proximity to contaminated supplies or equipment.

In the dialysis setting, additional measures should be taken to increase injection safety, including the following: preparing medications in a room or area separated from the patient treatment area and designated only for medications; not handling or storing contaminated supplies, equipment, blood samples, or biohazard containers in areas where medications and clean equipment and supplies are handled; and not using medication carts to deliver medications.

Of note, an outbreak of *Serratia liquefaciens* BSI was caused by accessing single-dose vials multiple times and pooling preservative-free epoetin alfa that was administered to multiple patients (14). As a result, it has been recommended that single-dose vials should be used to administer medication to only one patient and discarded promptly after use. Multidose vials should be assigned to a single patient when possible (15). The date of vial opening should be noted on a label to ensure viability of the product when used.

Transmission-Based Precautions: Droplet, Contact, and Airborne Precautions

Transmission-Based Precautions, the second tier of basic infection control, are used in addition to Standard Precautions for patients who may be infected or colonized with infectious agents for which additional precautions are needed to prevent isolation transmission (16). There are three categories of Transmission-Based Precautions: Contact Precautions, Droplet Precautions, and Airborne Precautions. Transmission-Based Precautions are used when the route(s) of transmission is (are) not completely interrupted by the use of Standard Precautions alone. For some diseases that have multiple routes of transmission (*e.g.*, SARS), more than one Transmission-Based Precaution category may be used. When used either singly or in combination, they are always used in addition to Standard Precautions. Transmission-Based Precautions are implemented judiciously in acute care settings. In outpatient settings such as dialysis facilities, full implementation is not always possible. For example, most outpatient dialysis facilities do not have the physical building requirements to care for patients requiring airborne infection isolation.

Contact Precautions are used to prevent transmission of infectious agents that are spread by direct or indirect contact with the patient or the patient's environment. An example of a situation that requires Contact Precautions in an acute care setting would be a patient infected or colonized with multidrug-resistant organisms (MDROs). In acute care and outpatient dialysis facilities, Contact Precautions will additionally apply in the presence of excessive wound drainage, fecal incontinence, or other bodily discharges that could potentially and extensively contaminate the environment, producing a substantial transmission risk.

With all contact precautions:

- Ensure appropriate patient placement; single-patient room when available; maintain at least 3 feet spatial separation in the dialysis station where possible, or dialyze the patient at a station with as few adjacent stations as possible (*e.g.*, at the end or corner of the unit).
- Use PPE appropriately, including dedicated PPE for use on the patient. Don PPE upon entry, and properly discard PPE before exiting (if single-patient room available).
- Limit transport and movement of patients. In dialysis facilities, patients should be placed in their treatment locations as soon as possible to limit environmental contamination and exposure of other individuals.
- Use disposable or dedicated patient care equipment.
- Prioritize cleaning and disinfection of the rooms/stations.

Droplet Precautions are intended to prevent the transmission of pathogens spread through respiratory or mucous membrane contact with respiratory secretions. Pertussis, influenza virus, adenovirus, rhinovirus, *Niesseria meningitides*, and group A streptococci (for the first 24 hours of antimicrobial therapy) generally do not remain infectious over long distances, and special air handling and ventilation are not required.

With all Droplet Precautions:

- Ensure appropriate patient placement; single-patient room when available; maintain at least 3 feet spatial separation in the dialysis station where possible or dialyze the patient at a station with as few adjacent stations as possible (*e.g.*, at the end or corner of the unit).
- Use PPE appropriately; don mask upon entry.

- Source control: put a mask on the patient and instruct in respiratory hygiene/cough etiquette.

Airborne Precautions prevent transmission of infections that remain infectious over long distances when suspended in the air (*e.g.*, rubeola virus, varicella virus, *M. tuberculosis*, and SARS). Patients requiring Airborne Precautions should be placed in an airborne infection isolation room (AIIR), a room equipped with special air handling and ventilation capacity. In settings where an AIIR is not available (*e.g.*, outpatient setting, physician's office), including outpatient HD facilities, the patient should wear a surgical mask and be placed in a private room with the door closed, and healthcare personnel should be provided with N95 or higher-level respirators or masks, if respirators are not available. This will reduce the likelihood of airborne transmission until the patient is transferred to a facility with an AIIR or returned to the home environment. After the patient exits the room, it should remain vacant to allow for full exchange of air, generally for an hour. Whenever possible, nonimmune healthcare workers should not care for patients with vaccine-preventable airborne diseases (*e.g.*, measles, chickenpox, and smallpox). Dialysis facilities should develop systems (*e.g.*, triage, signage) to identify patients with known or suspected infections that require Airborne Precautions upon entry.

With all Airborne Precautions:

- Airborne infection isolation room (AIIR).
- If an AIIR is not available, place a surgical mask on the patient, and place the patient in a private room with door closed.
- Use PPE appropriately, including fit-tested National Institute of Safety and Health N95 or higher respirators or masks, if respirators are not available for healthcare personnel.
- Respiratory protection program that includes education on use of respirators, fit-testing, and user seal checks is required in any facility with an AIIR.
- Limit transport and movement of patient.

Immunize susceptible persons as soon as possible after unprotected contact with vaccine-preventable infections.

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Vaccination for Influenza

After completing estimates for the 2015–2016 influenza season, the CDC estimated that since 2010, this virus annually produced between 9.2 million and 60.8 million cases of illness, between 140,000 and 710,000 hospitalizations, and between 12,000 and 56,000

deaths (1). Whereas influenza seasons vary in severity, during most seasons, people 65 years and older experience the greatest burden of severe disease. Although people in this age group accounted for only 15% of the United States population, they made up 50% of influenza-associated hospitalizations and 64% pneumonia and influenza—related deaths during the 2015–2016 season. Influenza vaccination is the best way to prevent infection, and the CDC estimates that among adults 65 years and older, vaccination prevented 23% of influenza-related hospitalizations during the 2015–-2016 season (1). Patients with ESRD are similarly considered to be at higher risk of illness and death from influenza-related illness relative to healthy adults (2). For more than 45 years, trivalent inactivated influenza vaccine has been recommended by the Advisory Committee on Immunization Practices for patients with ESRD (3). Seasonal influenza vaccination has become routinely offered at most dialysis clinics during the past two decades, with the proportion of patients vaccinated varying widely across outpatient HD facilities despite indications of effectiveness (4).

Much of the impetus to expand influenza immunization programs has been prompted by a desire to reduce serious complications of influenza infections, including death. Trials assessing influenza-associated mortality that may include randomly withholding vaccination are not practical. Some may consider such a practice unethical. In dialysis patients, the evidence of effectiveness has been based on observational studies that contain inherent biases (5). A systematic review and compilation of these studies are shown in Table 6.

Although it is true that the evidence for effectiveness of vaccines in ESRD is observational, most studies tend to indicate benefit. Furthermore, the susceptibility of patients receiving dialysis, coupled with the high rate of morbidity and mortality, support the CDC and CMS initiatives to increase vaccination coverage among patients with ESRD. In the general population, there is evidence to support greater overall impact of a "herd effect" when near-universal immunization for influenza occurs (6). Other suggestions toward improving effectiveness stems from improving vaccine efficacy, including use of high-dose vaccines in older patients. Compared with standard trivalent influenza vaccine, the high-dose vaccine improved mortality and influenza-related hospitalization rates in the non–ESRD Medicare population aged ≥65 years (7,8). A finding of lower rates of hospitalization for all causes was reported in an observational cohort of HD patients (particularly significant for those aged μ65 years) who were given high-dose trivalent vaccine relative to standard-strength trivalent and quadrivalent formulations, which has led to increasing use of high-dose influenza vaccines within the dialysis provider organization over consecutive influenza seasons (9).

Currently, the CDC reports that although the timing and intensity of influenza virus circulation for an influenza season cannot be predicted, peak weeks of influenza activity have occurred between December and February during about 75% of seasons over the past 30 years, and significant circulation of influenza viruses can occur as late as May. Therefore, vaccination should be offered to anyone aged ≥6 months by the end of October, if possible, and for as long as influenza viruses continue to circulate (1). The CDC does not specify a preferred formulation of inactivated vaccine for patients receiving dialysis, including high-dose vaccine in persons aged 65 years and older. Of importance to Medical Directors, the QIP now requires reporting of vaccination rates for outpatient HD facility healthcare staff to NHSN (10), consonant with the Healthy People 2020 goal of vaccinating 90% of healthcare personnel (10,11). The CDC recommends that all persons 6 months and older receive annual vaccination, and preventing influenza infections among contacts of persons with ESRD could benefit patients. If an employee refuses vaccination for influenza, some hospitals and providers have required refusers to wear masks during the influenza season.

Vaccination for Pneumococcal Disease

The CDC reports a decline in diseases caused by Streptococcus pneumoniae (pneumococcus) in adults since the start of this millennium, when the first-generation, 7-valent pneumococcal conjugate vaccine was introduced for routine use among children (12). Pneumococcal 13-valent conjugate vaccine (PCV13) was introduced in 2012 for use among adults 19 years or older with immunocompromising conditions and in 2014 for adults 65 years or older. Contrary to popular belief, PCV13 was not protective against primary infection but was for the dissemination of pneumococcus. However, declines in invasive pneumococcal

Table 6. Pooled crude and adjusted odd ratios for influenza-related outcomes during influenza season and off season in vaccinated vs. nonvaccinated ESRD participants

Outcome	Study (Reference)	Crude OR (95% CI)	Adjusted OR (95% CI)	Off-Season Adjusted OR (95% CI)	Risk of Bias
Mortality					
All-cause mortality					
	Bond et al.[a] (20)	0.79 (0.72–0.87)	0.73 (0.67–0.81)[b]	0.90 (0.77–1.10)[b]	Unclear
	Gilbertson[c] (27)	-	0.77 (0.65–0.90)[d]		High
	McGrath (26)	0.77 (0.76–0.78)[e]	0.71 (0.70–.72)[e]	0.45 (0.41–0.50)[f]	High
	Wang (28)	0.88 (0.73–1.07)[g]	0.49 (0.41–0.59)[g]	-	High
	Pooled estimate	0.77 (0.75–0.80), $I^2 = 10\%$	0.68 (0.61–0.76), $I^2 = 83\%$	-	-
Cardiac death[h]					
	Gilbertson[c] (27)	-	0.84 (0.71–0.98)[d]	-	High
Infectious death[i]					
	Gilbertson[c] (27)	-	0.83 (0.65–1.05)[d]	-	High
Hospitalization					
All-cause hospitalization					
	Gilbertson[c] (27)	-	0.95 (0.85–1.07)[h]		High
	Wang (28)	1.11 (0.96–1.28)[g]	0.80 (0.69–0.94)[g]	-	High
	Pooled estimate	-	0.88 (0.74–1.04), $I^2 = 70\%$	-	-
Hospitalization due to influenza or pneumonia					
	Gilbertson[c] (27)	-	0.90 (0.70–1.16)[d]		High
	McGrath (26)	0.90 (0.87–0.92)[5]	0.84 (0.82–0.84)[e]	0.74 (0.64–0.85)[6f]	High
	Slinin (29)	-	0.93 (0.86–1.01)	-	High
	Wang (28)		0.77 (0.64–0.93)[g]	-	High
	Pooled estimate		0.86 (0.80–0.93), $I^2 = 58\%$		-
Hospitalization due to bacteremia, viremia, or septicemia					
	Gilbertson[c] (27)	-	0.73 (0.32–1.68)[d]	-	High
Hospitalization due to respiratory infection					
	Gilbertson[c] (27)	-	0.87 (0.69–1.09)[d]	-	High
ICU admission					
	Wang (28)	0.38 (0.27–0.53)[g]	0.19 (0.14–0.27)[g]	-	High
Other outcomes					
Influenza-like illness					
	McGrath (26)	0.93 (0.91–0.95)[e]	0.88 (0.86–0.90)[e]	0.77 (0.68–0.88)[f]	High

Reprinted with permission from reference 5 (Remschmidt C, Wichmann O, Harder T: Influenza vaccination in patients with end-stage renal disease: systematic review and assessment of quality of evidence related to vaccine efficacy, effectiveness, and safety. *BMC Med* 12:244, 2014). CI, confidence interval; ICU, intensive care unit; OR, OR, odds ratio.

[a]OR were also reported for those who additionally received pneumococcal vaccine; however, for the purpose of this study these patients were not considered.

[b]Off-season estimates in months June–August.

[c]Only patients on peritoneal dialysis.

[d]Point estimates of two influenza seasons were pooled first.

[e]Point estimates of four seasons were pooled first.

[f]Point estimates of four pre-influenza seasons (defined as 10% of isolates positive for influenza) were pooled first.

[g]Crude/adjusted incidence rate ratios.

[h]Cardiac death, defined according to cause of death reported on the ESRD death notification form (myocardial infarction, pericarditis, atherosclerotic heart disease, cardiomyopathy, cardiac arrhythmia, cardiac arrest, valvular heart disease, pulmonary edema).

[#i]Infectious death, defined according to cause of death reported on the ESRD death notification form (septicemia, pulmonary infection, viral infection, tuberculosis, hepatitis B, other viral hepatitis, fungal peritonitis, other infections).

disease (IPD) were noted as early as 2001 among adults between the ages of 19 and 64 years and adults 65 years old or older (13).

Notably, IPD caused by the serotypes covered by PPSV23 also declined, although these reductions were due to declines in IPD caused by serotypes in common with PCV13, whereas no changes were observed in disease caused by serotypes unique to PPSV23. PPSV23 has been available since 1984 and is recommended for all adults 65 years of age or older and for persons 2 years or older with chronic medical conditions, including ESRD.

Mortality from pneumonia has historically been reported to occur at a rate 14 to 16 times higher in HD patients than in the general population (14). The all-cause pneumonia incidence rate in dialysis patients was 27.9/100 patient-years (29.0 in HD versus 18.2 in peritoneal dialysis patients ($P<0.0001$)) and remained relatively constant from year to year in 289,210 patients who initiated dialysis in the United States between 1996 and 2001 and were followed up until year-end 2003 (13). The 6-month mortality rates after pneumonia in patients during the first year of dialysis were 78.3/100 patient-years in 2001 (15). The relative risk for death at 6 months in first-year dialysis patients who experienced an episode of pneumonia was 5.1 (95% confidence interval [CI], 4.9 to 5.2; $P<0.0001$) compared with patients who did not. The increase in mortality persisted 48 months after the event, with an adjusted relative risk for death in patients with pneumonia of 1.82 (95% CI, 1.66 to 2.0; $P<0.0001$) compared with patients without pneumonia (Figure 9).

Similarly, the risk for cardiovascular events in the first 6 months also was greater at 3.02 (95% CI, 2.87 to 3.02; $P<0.0001$) in dialysis patients with pneumonia compared with individuals without pneumonia (16). Therefore, the complications and sequelae of pneumonia in dialysis patients are quite devastating. One caveat: pneumonia-causing pathogens are not always identifiable, but the majority of positive bacterial results in CKD (including dialysis) hospitalizations involve *S. pneumoniae* (17).

Despite the high mortality and increased cardiovascular event rates associated with pneumonia, immunization rates of ESRD patients with pneumococcal vaccine remain low. In 2001, pneumococcal vaccine was offered to patients at only 58.5% of dialysis centers in the United States. Overall, the estimated percentage of dialysis patients vaccinated for *S. pneumoniae* in 2001 was 26.2% compared with 65% for

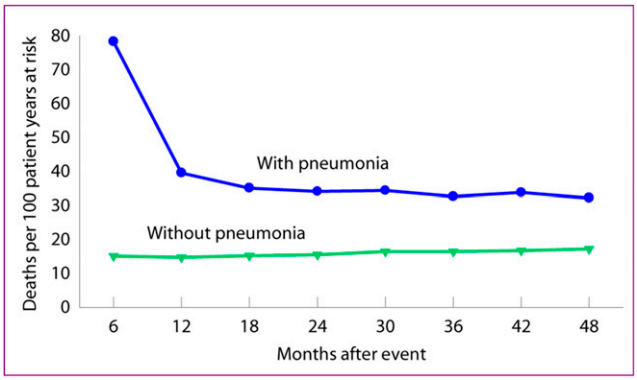

Figure 9. Increased risk for death observed in incident dialysis patients after pneumonia Incident dialysis patients, 1996–2000, with 90-day rule & with Medicare Parts A & B as primary payor; adjusted rates adjusted for age, gender, race, primary diagnosis, & vintage. Patients without pneumonia during the first year + 90 days after initiation are used as the reference cohort. Reprinted with permission from reference 15 (USRDS 2004 annual data report. U.S. Renal Data System, USRDS 2004 Annual Data Report: Atlas of End-Stage Renal Disease in the United States, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2004. https://www.usrds.org/2004/pdf/06_hosp_morte_04.pdf).

influenza (18). In an observational study, mortality and hospitalization rates among prevalent HD patients who survived for at least 2 years between 2003 and 2005 were compared between the 21% who received pneumococcal vaccine and those who did not (19). Pneumococcal vaccination was associated with a statistically significant decrease in mortality hazard (hazard ratio [HR], 0.94; 95% CI, 0.90 to 0.98), cardiac death (HR, 0.91; 95% CI, 0.85 to 0.97), and hospitalization for bacteremia/viremia/septicemia (HR, 0.95; 95% CI, 0.91 to 1.00). The mortality hazard was 0.73 (95% CI, 0.68 to 0.78) for patients who received pneumococcal and influenza vaccinations, indicating potential synergy when both vaccines were administered to HD patients (19).

These findings were confirmed in a cohort of 36,966 patients receiving dialysis for at least 1 year as of December 31, 2005, from ESRD Networks 6, 11, and 15 (20). For the 2005 to 2006 season, the adjusted odds ratio of all-cause mortality for influenza vaccine alone was 0.79 (95% CI, 0.72 to 0.86) compared with no vaccination. The adjusted odds ratio for co-administration of influenza and pneumococcal vaccines was 0.70 (95% CI, 0.62 to 0.78) compared with no vaccination, implying that both influenza and pneumococcal vaccines prevent deaths and have a synergistic

effect (Figure 10). Of note, there is the possibility of a bias due to a healthy patient effect, *i.e.*, healthier patients are more likely to get vaccinated.

Most of the foundational ESRD data on pneumonias are almost two decades old. A recent report included data for 103,581 incident patients in 2013 and prevalent patient data from 2012 for the Peer Kidney Care Initiative (21). Rates of hospitalization for pneumonia and influenza since then have not changed appreciably in either incident or prevalent patients at approximately 8 hospitalizations per 100 patient-years (Figure 11). Even more detail from 90,862 pneumonia episodes documented by physicians were characterized in 39,988 of 231,202 Medicare patients treated in a large dialysis provider organization from 2009 to 2011 (22). The bulk of episodes (81,883 of 90,862; 90.1%) required inpatient treatment. This corresponded to an incidence rate of 19.3 events per 100 patient-years. A total of 8979 episodes required outpatient treatment only (incident rate, 2.1 events per 100 patient-years). Overall, the median episode length was approximately 11 days. Episodes requiring inpatient treatment were longer (median episode length, 12 days), which included a median hospital length of stay of 8 days. The overall 30-day and 180-day case fatality rates were 10.7% and 24.8%. Mean episode duration and mortality rates increased with age (22). The potential for waning antibody titers in ESRD has led to suggestions for booster vaccinations to improve response rates and duration of vaccine effect. These recommendations were made without considering current recommendations to add PCV13 immunization to prior PSV23 immunizations. No outcomes from such strategies have been reported in the ESRD population (23).

Among Medicare beneficiaries aged ≥65 years continuously enrolled in Medicare Parts A and B during annual periods beginning September 19, 2009, until September 18, 2016, 43.2% had received ≥1 dose of PPSV23, 31.5% had received ≥1 dose of PCV13, and 18.3% had received both by September 18, 2016 (24). Receipt of either type of pneumococcal vaccine was highest among beneficiaries who were older, were white, or had chronic and immunocompromising medical conditions such as ESRD. Corresponding rates of vaccination in patients with chronic conditions were 50.7% for ≥1 dose of PPSV23, 35.1% for ≥1 dose of PCV13, and 21.8% for both. Claims for PPSV23 vaccination were persistently low despite longstanding recommendations for its use among adults aged >65 years and patients with chronic conditions like ESRD.

With such low vaccination rates and continuing high morbidity and mortality attributable to influenza and pneumonia, it is important for nephrologists to be even more proactive and to improve vaccination rates in patients receiving maintenance dialysis (25). Generally, PCV13 is now recommended as the first pneumococcal vaccine to be given for adult patients under 65 years of age, then followed by PPSV23 8

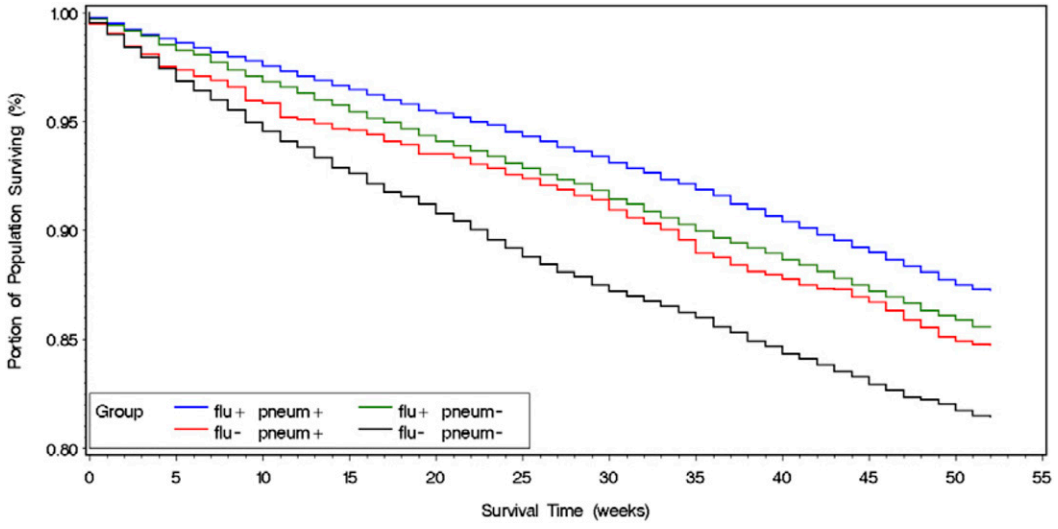

Figure 10. Mortality by immunization status in HD patients: influenza and pneumococcal vaccination. Groups labeled as + (vaccine given) and – (no vaccine given). Vaccines: flu, influenza; pneum, pneumonia. Reprinted with permission from reference 20 (Bond TC, Spaulding AC, Krisher J, McClellan W: Mortality of dialysis patients according to influenza and pneumococcal vaccination status. *Am J Kidney Dis* 60: 959-65, 2012).

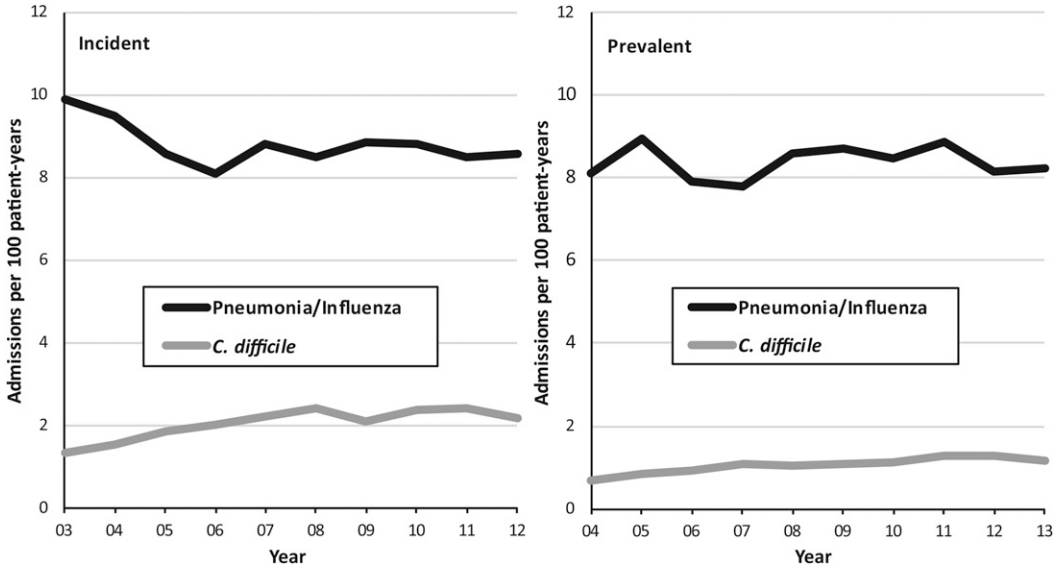

Figure 11. Annual rates of hospitalizations with primary discharge diagnosis of pneumonia/influenza or *Clostridioides difficile* (*C. difficile*) for incident and prevalent maintenance dialysis patients. Reprinted with permission from reference 21 (Wetmore JB, Li S, Molony JT, Guo H, Herzog CA, Gilbertson DT, Peng Y, Collins AJ. Insights from the 2016 peer kidney care initiative report: still a ways to go to improve care for dialysis patients. *Am J Kidney Dis* 71: 123-132, 2018).

weeks later. PPSV23 can be given again 5 years later (but only a single lifetime dose of PCV13 is recommended). For persons receiving dialysis who have never received PCV13, administer the dose at least 1 year apart from the last PPSV23 dose (assuming most ESRD patients are scheduled to receive or have already received a dose of PPSV23 vaccination). In the situation where patients ≥65 years of age also require PPSV23 to be given, administer PCV13 first; then, 8 weeks later, administer PSV23 (25).

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Specific Prevention Strategies for Outpatient Hemodialysis Facilities

Environmental Cleaning and Disinfection

The outpatient hemodialysis (HD) setting presents a unique environmental challenge because of the spatial arrangement of patients and the temporal demands of multiple shifts. No physical barriers can exist between dialysis stations to prevent potential cross-contaminations. This requirement, coupled with the proximity of patients, creates challenges in infection control. The CMS has specific rules for outpatient HD facilities that cover infection control in their Conditions for Coverage (CfC) of ESRD: https://www.govinfo.gov/content/pkg/CFR-2010-title42-vol5/pdf/CFR-2010-title42-vol5-sec494-30.pdf (Section 494.3) (1).

Documented in the CfC are components of a comprehensive infection control program to prevent transmission of infections among chronic HD patients. The components include the following:

- Infection control practices for hemodialysis units
  - Infection control precautions specifically designed to prevent transmission of bloodborne viruses and pathogenic bacteria among patients.
  - Routine serologic testing for hepatitis B virus infections.
  - Vaccination of susceptible patients and staff against hepatitis B virus.
  - Isolation of patients whose test results for hepatitis B surface antigen are positive.
- Surveillance for infections and other adverse events.
- Infection control training and education.

Compliance with infection control and prevention can be complicated by conditions such as the shortage of nurses and an inadequate number of dialysis technicians, rapid turnaround times from patient seatings, and the intensive process of dialysis. In a typical hospital setting, terminal cleaning of each vacated patient room is performed by trained staff dedicated to the function of ensuring that the room is properly and completely disinfected between treatments. A typical dialysis unit has no availability of such environmental service staff. Instead, the nurse or dialysis technician must participate and perform the housekeeping task of surface disinfection (*e.g.*, machine, chair, chart, jugs) in the short intervals between patient seatings.

A facility should establish written protocols for cleaning and disinfecting surfaces and equipment, including careful mechanical cleaning before any disinfection process, as explicitly mandated within the CMS ESRD Program Interpretative Guidelines, tag V122 (2). The instruction is this: “Any manufacturer’s guidance for sterilization or disinfection of an item should be followed, as well as guidance from the chemical sterilant or disinfectant manufacturer, including appropriate dilution and contact time.” Required cleaning and disinfection of environmental surfaces, including patient chair or bed surfaces, dialysis equipment surfaces to include blood pressure cuffs and prime buckets, and adjacent tables and work surfaces, must be

performed between patient uses to prevent transmission of dangerous pathogens. Short intervals during patient changeovers are particularly prone to error and can contribute to the risk of cross-contamination if correct procedures are not observed. Therefore, sufficient time must be available between the completion of one patient's treatment and postdialysis care and the initiation of the next patient's dialysis session to permit appropriate and sufficient disinfection. Citing CDC recommendations, the CMS mandates that the station must be completely vacated by the patient before station disinfection and remain so until completion of the setup for the next patient (3).

According to the CMS (4), all surfaces without visible blood should be subjected to a low-level disinfection protocol with soap, detergent, or detergent germicide. Specifically, noncritical surfaces (*e.g.*, dialysis bed or chair, countertops, external surfaces of dialysis machines) and equipment (*e.g.*, scissors, hemostats, clamps, blood pressure cuffs, stethoscopes) should be disinfected with an EPA-registered disinfectant unless the item is visibly contaminated with blood (5). Blood spills in the treatment area and other areas such as the waiting room and patient bathroom should be cleaned effectively and immediately, or as soon as possible. An intermediate-level disinfection protocol must be followed, which requires the area to be immediately cleaned with a cloth soaked with tuberculocidal disinfectant or 1:100 dilution of bleach (300–600 mg/L free chlorine) when visible blood is present on surfaces. When blood has been removed, a second application of disinfectant must be applied with a new cloth or towel. A description of the recommended level of disinfection based on the type of item/surface is shown in Table 7 (4). Of note, the disinfection procedures described in this section apply only to typical dialysis station disinfection. More stringent procedures should be followed for those patients who have been identified as needing isolation precautions, following the CDC Guideline for Isolation Precautions.

A typical outpatient HD facility floor plan positions multiple dialysis patients in and around a designated open area. The patient area contains the dialysis chair, dialysis machine, and any other ancillary items necessary to provide the treatment. The space for each dialysis station or seating must be considered the patient's exclusive treatment area. The proximity of patients to one another without the boundary of walls provides opportunity for sharing items between patients—a practice to be avoided. Any equipment or item used for any patient must be considered as if it had been taken to a patient's private room and should not be shared from patient to patient without proper disinfection. Along with the dialysis machine and dialysis chair, staff must clean and disinfect items such as scissors, hemostats, clamps, stethoscopes, blood pressure cuffs, and priming buckets between patient uses. Disposable dialysis supplies brought to the patient's station should be appropriately discarded after each treatment, if not after use. A standardized process and procedure should be documented, and the staff trained to ensure routine performance. These procedures can be audited, reviewed, and updated periodically by the facility leadership.

Table 7. Disinfection procedures recommended for commonly used items or surfaces in hemodialysis units

Item or Surface	Low-Level Disinfection[a]	Intermediate-Level Disinfection[a]
Gross blood spills or items contaminated with visible blood		X
Hemodialyzer port caps		X
Interior pathways of dialysis machine		X
Water treatment and distribution system	X	X[b]
Scissors, hemostats, clamps, blood pressure cuffs, stethoscopes, prime buckets	X	X[c]
Environmental surfaces, including exterior surfaces of hemodialysis machines	X	

From Centers for Disease Control and Prevention: Recommendations for preventing transmission of infections among chronic hemodialysis patients. *MMWR Recomm Rep* 50(RR-5): 1-43, 2001. https://www.cdc.gov/mmwr/pdf/rr/rr5005.pdf

[a]Careful mechanical cleaning to remove debris should always be done before disinfection.

[b]Water treatment and distribution systems of dialysis fluid concentrates require more extensive disinfection if significant biofilm is present within the system.

[c]If item is visibly contaminated with blood, use a tuberculocidal disinfectant.

The current technology of single-pass HD machines allows for daily disinfection. The HD machine operator has the option of performing heat disinfection or chemical disinfection of the internal hydraulic pathways. Guided by the manufacturer's instructions, disinfection should be performed daily by a chemical (*e.g.*, bleach) or heat method. Disinfection of the machine's internal pathways is routinely performed at the end of each treatment day. According to the shared CDC and CMS requirements, a dialyzer blood leak requires mandatory disinfection of the dialysis machine's internal pathways between patient treatments because the integrity of the ultrafilter is violated, permitting blood contamination of the internal pathways (4).

Opportunities for lapses in infection control practice are enhanced by the confined space between patients in the setting of multiple dialysis shifts that reuse equipment within the demands of rigorous treatment schedules. Future design of outpatient hemodialysis facilities should consider sufficient spacing to allow for unimpeded implementation of recommended disinfection processes and other infection control and prevention practices.

Vascular Access Care

Among the most common three types of accesses, studies show that central venous catheters (CVCs) compared with arteriovenous fistulas/grafts (AVFs/AVGs) have the highest risk of infections in HD patients. Up to 80% of patients initiating long-term HD in the United States begin with a CVC (7). Early referral to a nephrologist reduces the initiation of HD with a CVC, but the rate of starting long-term HD with a CVC is reduced only by less than half (8). The Fistula First Initiative has raised the level of awareness that AVFs should be constructed months before they may be used, consonant with National Kidney Foundation KDOQI recommendations (9,10).

AVGs may represent a reasonable alternative, especially in older patients with multiple comorbidities that may preclude proper AVF maturation (11). Steps to lessen the use of CVCs include early referral of patients with stages 4 to 5 CKD to a nephrologist, CKD patient education classes, and a practice-based vascular access champion such as a nurse, physician assistant, or advanced practice provider who will oversee transitions of care from stage 4 to 5 CKD to ESRD and long-term dialysis. The CDC Dialysis Patient Pocket Guide (https://www.cdc.gov/dialysis/PDFs/Dialysis-Patient-PocketGuide.pdf) is an example of a useful tool for patient education that provides information on access types and how to prevent infections (12). If a CVC cannot be avoided, the CDC recommends insertion site skin preparation with an alcohol-based chlorhexidine (>0.5%) solution. For those patients sensitive to chlorhexidine, a povidone-iodine solution or 70% alcohol can be used. Tunneled catheters are preferred because of their lower infection rates and longer efficacy with repeated use (10).

Reducing Infections

During the dialysis procedure, patients can be exposed to risk for serious infection, regardless of access type. Steps within the dialysis procedure identified at highest exposure risk include skin antisepsis of a catheter exit site, connection of a CVC, cannulation of a vascular access, during disconnection of a catheter or decannulation of an AVF or AVG, and during medication preparation and medication administration. Extra caution should be taken by staff caring for patients to increase compliance with published guidelines and facility procedures, designed to decrease the risk of infections during performance of these steps. Medical Directors should understand the importance of auditing, observing, and providing open and honest infection prevention feedback to staff.

Arteriovenous Fistulas and Grafts

Before accessing an AVG or AVG, staff must assess the access site for infection, documenting pain/tenderness, redness, swelling, bleeding, or discharge. If no infection signs are noted, then precannulation skin antisepsis is performed. This can be accomplished with alcohol-based chlorhexidine, 10% povidone-iodine, 70% alcohol, or sodium hypochlorite (Table 8). Irrespective of the skin antiseptic used, it must dry completely to optimally kill skin bacteria. These agents have been reviewed and compared by Kapoian and colleagues (6).

After the antiseptic is applied and dries, aseptic access cannulation proceeds. Decannulation at treatment-end follows aseptic HD machine disconnection. Staff typically place an adhesive bandage or gauze over the insertion site, and pressure is applied after

Table 8. Common skin antiseptics used in dialysis before cannulation

Product (Refer to Manufacturer Directions for Specific Product Used)	Example Descriptions of Use	Notes
Chlorhexidine gluconate with Alcohol	30-second scrub or friction application, then allow to dry.	One of the main benefits of using an alcohol-based chlorhexidine solution when cleaning the skin over an access is that it dries quickly (usually in 30 seconds), allowing for efficient access cannulation. CDC recommends use of >0.5% chlorhexidine with alcohol.
Povidone iodine	Apply using friction for 2–3 minutes, then allow to dry.	Relatively long contact and dry times. CDC recommends use of 10% povidone iodine.
Alcohol	Use a 60-second rubbing motion on each site immediately before cannulation.	Short contact and dry times. Cannulation can occur shortly after applying. CDC recommends 70% alcohol.
Sodium hypochlorite solution	Apply using a circular motion for 2 minutes, then allow to dry (2 minutes). Follow with 15 second 70% alcohol scrub.	Relatively long contact and dry times. Requires 2-step process, with application of additional antiseptic (alcohol).

Summarized with permission from reference 6 (Kapoian T, Meyer KB, Johnson DS: Infection prevention and the medical director: uncharted territory. *Clin J Am Soc Nephrol* 10: 863–874, 2015.

CDC, Centers for Disease Control and Prevention.

needle removal. After sufficient clotting occurs and the patient is in stable condition, the patient may be discharged from the clinic.

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Buttonhole Technique

Regarding the relatively rare occurrence of arteriovenous fistula (AVF) infection is a needle insertion technique known as the buttonhole technique. This technique uses the same cannulation sites as AVFs during each hemodialysis session and involves lifting off the previously formed scab and guiding the

needle into and through the same subcutaneous track. The buttonhole technique uses blunt-tip needles to minimize vascular damage. This method was anecdotally associated with ease of cannulation, less pain, more rapid hemostasis, and less tendency to the creation of aneurysms and hematomas (1). However, a systematic review of 23 studies contrarily disclosed that buttonhole cannulation does not significantly alleviate cannulation pain (most studied) and may increase the risk of potentially serious infectious complications (2). Furthermore, the authors identified three studies reporting within-group improvement in infectious complications when the buttonhole technique was subjected to stricter procedures. A buttonhole educational workshop for nursing staff was conducted, or mupirocin prophylaxis cream was introduced to mitigate buttonhole infection rates. However, the event rates of buttonhole patients were still greater than those of the rope-ladder comparator groups despite measures to mitigate infection risk (2).

A recent prospective cohort study of colonization in 84 HD patients using the buttonhole technique revealed that 38% of patients had at least one positive culture from the buttonhole tract. Growth from the cannulation tract and/or cannula tip at each of the three monthly sets of cultures was found in 18%, 20%, and 17% of patients, respectively. Staphylococcal species were the most common pathogens (*S aureus*, 25%; and *S epidermidis,* 41%) (3). Buttonhole sites with bulging deformities have a markedly increased risk of access-related infections than sites with a flat and uniform entry (4). It was postulated that when proliferation of the colonizing pathogen reaches critical mass to overcome host defenses, local or systemic infections develop (5). In summary, routine use of the buttonhole technique is not recommended because of its high infection risk and uncertain benefit. Its efficacy, in parallel with measures to decrease infection risk, may be explored further in specific cases where the standard rope-ladder cannulation technique is not feasible (6).

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Central Venous Catheters

Access of CVCs for HD is performed by the use of aseptic technique at all times. After the catheter cap is removed, a "scrub the hub" protocol is initiated with an antiseptic. As described in the 2011 CDC/Healthcare Infection Control Practices Advisory Committee (HICPAC) Guidelines for the Prevention of Intravascular Catheter-Related Infections, >0.5% chlorhexidine with alcohol, 70% alcohol, or 10% povidone-iodine can be used (1). This process has been shown to decrease BSI rates in a large cluster-randomized trial in more than 400 outpatient HD facilities (2). This cleaning should occur before attaching items such as sterile saline syringes or medications. The entire "scrub the hub" process should be repeated for the second catheter limb using new antiseptic pads. If there is a question that aseptic technique has been broken, the protocol is repeated. Last, dialysis tubing can be attached to the hub of the catheter to initiate treatment. With needleless connectors, manufacturer recommendations for scrubbing these devices before accessing the catheter should be followed.

At the time of disconnection, the aseptic "scrub the hub" procedure is repeated, and the catheter is filled with either heparin or saline solution or gentamicin/citrate lock solution aseptically, clamped, and capped before the patient is discharged from the clinic. There are new emerging technologies surrounding the catheter caps, such as the chlorhexidine-eluting cap that shows further reduction of BSI rates as demonstrated in two studies with a total of 80 outpatient HD facilities in the group (3,4).

Exit Site Care

The CDC recommends skin antisepsis with an alcohol-based chlorhexidine solution as the preferred skin antiseptic solution for catheter exit site care (5). Povidone-iodine with alcohol or 70% alcohol is an

acceptable alternative for patients who experience adverse mucocutaneous or systemic reactions to chlorhexidine. The CDC also endorses application of a povidone-iodine or bacitracin/gramicidin/polymyxin B ointment to the site. The latter preparation is not available in the United States. Triple antibiotic ointment (bacitracin/neomycin/polymyxin B) is available and may provide a similar benefit. However, adequate studies that assess efficacy for prevention of bloodstream and exit-site infections are not available. Other ointments that have been studied include single-antibiotic ointments (*e.g.*, mupirocin); however, concerns exist about the development of antimicrobial resistance and the ability of these antibiotics to adequately cover the spectrum of potential pathogens (*e.g.*, gram-negative and gram-positive bacteria) that cause BSIs in HD patients (6). Chlorhexidine-impregnated dressings may represent a viable alternative to antimicrobial ointments (5).

The chemical components of each patient's catheter must be checked for interactions with the antibiotic ointment and cleaning agent used. The CDC has compiled a catheter list with ointment and cleaning agent compatibilities. Nonetheless, direct checking of manufacturer recommendations is advised. Individual HD catheters may vary in compatibility, both between manufacturers and within the different product lines from the same manufacturer. Some posit that ointment base (*i.e.*, ingredients such as alcohol and ethylene glycol) may react with the polyurethane in catheters and produce mechanical alterations (7), thereby leading to softening and catheter erosion with potential breakdown and leakage. Anecdotally this has led to bleeding complications (available at https://abdominalkey.com/hemodialysis-vascular-access/).

As a practical matter, it is often difficult to identify a CVC's identity, and details of the catheter may not be readily available in the medical record. A chlorhexidine gluconate-impregnated disc (Biopatch) or other chlorhexidine-impregnated dressings may be used in lieu of ointment, avoiding some of these challenges. Patients harboring long-term CVCs must have their alternatives periodically reviewed. Each patient's clinical and socioeconomic situation evolves over time, and the feasibility of alternative treatment modalities (*e.g.*, kidney transplantation or peritoneal dialysis) or re-evaluation for a permanent AV access may change while new technologies and novel surgical techniques become available. Nevertheless, patients who require life-saving HD with a CVC deserve the best care possible, including best practices to decrease the risk for access-related infections.

Update on Antimicrobial Locks and Caps for Hemodialysis Central Venous Catheters

HD patients with central venous catheters CVCs are at high risk of morbidity and mortality from BSIs (8). One major mechanism of the development of catheter-related infections is the formation of bacterial biofilms on the inner surface of indwelling HD catheters (9). These can be difficult to eradicate. Consequently, intense interest in determining mechanisms to reduce biofilm formation is an active area of bioscientific research. One technique is to lock catheters with an antimicrobial solution to kill bacteria and reduce biofilm formation (10). "Locking" a HD catheter refers to instillation of a solution into catheter lumens between dialysis sessions. Typically, an anticoagulant such as heparin or citrate is used to maintain patency.

Antibiotic antimicrobial locks are solutions that contain an antibiotic with an anticoagulant like heparin or citrate of varying concentrations, which can be used for prevention (singly) or treatment, usually with parenteral antibiotics, of HD catheter-related infections (11,12). In this section, the focus is on antibiotic antimicrobial locks used for prevention of infection. Various antibiotics like cefazolin, gentamicin, ceftazidime, and vancomycin have been used, and a list summarizing the composition of commonly used antibiotic locks is shown in Table 9.

Over the past decade, many studies have examined the safety and efficacy of using antimicrobial locks (AMLs) to prevent catheter-related BSIs (CRBSIs). Some of the major studies are summarized in Table 10 (13–19). Gentamicin as an AML solution is associated with a much lower risk of CRBSIs in five of seven studies. However, one of the major concerns from the study by Landry and colleagues (17) was that although CRBSIs decreased from 17 to 0.83 per 1000 catheter-days within the first year, cases of gentamicin-resistant infections occurred, leading to protocol discontinuation. Such findings have fueled apprehension regarding the emergence of multidrug-resistant (MDR) organisms with the use of AMLs, a problem that was not seen with the gentamicin/citrate protocol of Moore and colleagues (19).

Table 9. Concentration of various antibiotics used in antibiotic locks

Antibiotic Name	Antibiotic Concentration	Antibiotic Amount	Heparin Concentration	Heparin Amount	Normal Saline
Vancomycin	5 mg/ml	1 ml	1000 units/ml	1 ml	N/A
Ceftazidime	10 mg/ml	1 ml	1000 units/ml	1 ml	N/A
Cefazolin	10 mg/ml	1 ml	1000 units/ml	1 ml	N/A
Gentamicin	4 mg/ml	0.5 ml	10,000 units/ml	0.5 ml	1 mL
Vancomycin/ceftazidime	5 mg/ml of vancomycin and 10 mg/ml of ceftazidime	1 ml of vancomycin and 0.5 ml of ceftazidime	1000 units/ml	0.5 ml	N/A

Original table compiled from data in reference 11 (Allon, M: Treatment guidelines for dialysis catheter-related bacteremia: an update. *Am J Kidney Dis* 54 : 13-7, 2009) and reference 12 (Krishnasami Z, Carlton D, Bimbo L, Taylor ME, Balkovetz DF, Barker J, Allon M: Management of hemodialysis catheter-related bacteremia with an adjunctive antibiotic lock solution. *Kidney Int* 61: 1136-42, 2002).

The study by Moore et al. (19) compared gentamicin/citrate solution to heparin in 555 HD patients. Not only were CRBSIs in the antibiotic lock group lower, but there was a lower risk of mortality after multivariate adjustment (hazard ratio, 0.32; 95% confidence interval, 0.14 to 0.75), and the rate of gentamicin-resistant organisms reported was lower in the antibiotic lock group. However, use of gentamicin locks in New Zealand promotes caution when two consecutive reports spanning the periods 2003 to 2006 and 2006 to 2009 indicated a continued trend toward increasing gentamicin resistance in their HD populations (20,21).

In addition to concerns for resistance to AMLs, systemic toxicity with leakage of the AML solution into the systemic circulation may occur. One study has reported a frequency as great as 10% of ototoxicity associated with gentamicin-based AMLs (22). Another consideration for using AMLs routinely is that the CMS does not provide reimbursement for these solutions, resulting in an additional financial burden on the dialysis unit. One more critical issue involves how AMLs are prepared, avoiding the risk of microbial contamination and whether the compounding or mixing processes may be safely accomplished at outpatient dialysis centers (23).

Based on these concerns, the most recent CDC guidelines for prevention of intravascular catheter-related infections do not encourage the use of AMLs in all patients and restrict their recommendation to the HD populations with recurrent CRBSIs despite maximal application of aseptic technique (24). The most recent 2006 National Kidney Foundation Kidney Dialysis Outcomes Quality Initiative guidelines have no recommendation regarding AMLs (25). Overall, given the dearth of high-quality trial evidence for AMLs, the recommendations of these professional societies stand. Routine prophylactic use of AMLs is not recommended for all HD patients with CVCs. Multicenter randomized controlled trials with long-term follow-up are required to evaluate the efficacy, effectiveness, and safety of AMLs.

One way to mitigate the risk of potential resistance of AMLs is to apply alternative nonantibiotic antimicrobial solutions (26) Taurolidine, a derivative of the amino sulfonic acid taurine, fits these criteria. It is an antimicrobial agent with a broad spectrum of antimicrobial activity against both bacteria and fungi. When used as a nonantibiotic AML, taurolidine has been shown to reduce the risk of staphylococcal BSIs (27). Bacterial resistance has not been reported for this compound, which is more of a disinfectant than an antibiotic (28).

Other nonantibiotic AMLs that have been tried but not generally used include ethanol and trisodium citrate, which is antimicrobial at a concentration of 30% (v/v) (17,29). Moreover, a novel antimicrobial and antithrombotic solution with a combination of citrate, methylene blue, methylparaben, and propylparaben has shown promising results in reducing CRBSIs in a study of over 40 HD patients (30). The results of these studies are summarized in Table 11 (27,29,33–36) Most of these studies have shown nonsignificant trends toward reduction in CRBSIs. Overall, a recent meta-analysis of 17 randomized controlled trials showed that antibiotic and nonantibiotic AMLs were superior to heparin (relative risk, 0.32; $P<0.01$) for preventing catheter-related bacteremia (31). However, none of these solutions are currently approved by the U.S. Food and Drug Administration (FDA).

Table 10. Summary of studies using antibiotic antimicrobial locks

Study	Study Type	Number of Patients	Catheter-Days	Antimicrobial Lock Solution vs. Control	Catheter-Related Bloodstream Infection Rates (Antibiotic Lock Solution vs. Control)
Al-Hwiesh & Abdul-Rahman, 2007	Randomized controlled	63	N/A	Vancomycin + gentamicin + heparin vs. heparin	0.65 vs. 4.88 per 1000 dialysis sessions $P < 0.001$
Onder et al., 2009	Observational retrospective	45 pediatric patients	16,412	Tissue plasminogen activator/tobramycin vs. heparin	16.8 vs. 6.2 episodes per 1000 catheter-days, $P = 0.0201$
Zhang et al., 2009	Randomized controlled trial	140 patients	34,080	Gentamicin/heparin vs. heparin	0.06 vs. 0.67 per 1000 catheter-days, $P = 0.025$
Venditto et al., 2010	Observational retrospective	265	7452	Gentamicin + heparin vs. 46% citrate vs. heparin	0.4 for gentamicin + heparin vs. 3.4 for 46% citrate vs. 2.9 for heparin per 1000 catheter-days
Landry et al., 2010	Observational retrospective	1410	142,365	Gentamicin + heparin	0.83 vs. 17 per 1000 (rates after and before initiation of GHL)
Moran et al., 2011	Randomized controlled	303	72,760	Gentamicin + 4% sodium citrate vs. heparin	0.28 vs. 0.91 episodes per 1000 catheter-days $P = 0.003$
Moore et al., 2014	Observational prospective	555	155,518	Gentamicin + 4% sodium citrate vs. heparin	0.45 vs. 1.68 episodes per 1000 catheter-days

Data compiled from reference 13 (Al-Hwiesh AK, Abdul-Rahman IS: Successful prevention of tunneled, central catheter infection by antibiotic lock therapy using vancomycin and gentamicin. Saudi J Kidney Dis Transpl 18: 239–247; 2007), reference 14 (Onder AM, Chandar J, Billings A, Simon N, Gonzalez J, Francoeur D, et al: Prophylaxis of catheter-related bacteremia using tissue plasminogen activator-tobramycin locks. Pediatr Nephrol 24: 2233–2243; 2009); reference 15 (Zhang P, Yuan J, Tan H, Lv R, Chen J: Successful prevention of cuffed hemodialysis catheter-related infection using an antibiotic lock technique by strictly catheter-restricted antibiotic lock solution method. Blood Purif 27: 206–211 2009), reference 16 (Venditto M, du Montcel ST, Robert J, Trystam D, Dighiero J, Hue D, et al: Effect of catheter-lock solutions on catheter-related infection and inflammatory syndrome in hemodialysis patients: heparin versus citrate 46% versus heparin/gentamicin. Blood Purif 29: 268–273; 2010), reference 17 (Landry DL, Braden GL, Gobeille SL, Haessler SD, Vaidya CK, Sweet SJ: Emergence of gentamicin-resistant bacteremia in hemodialysis patients receiving gentamicin lock catheter prophylaxis. Clin J Am Soc Nephrol 5: 1799–1804; 2010), reference 18 (Moran J, Sun S, Khababa I, Pedan A, Doss S, Schiller B: A randomized trial comparing gentamicin/citrate and heparin locks for central venous catheters in maintenance hemodialysis patients. Am J Kidney Dis 59: 102–107; 2012), and reference 19 (Moore CL, Besarab A, Ajluni M, Soi V, Peterson EL, Johnson LE, et al: Comparative effectiveness of two catheter locking solutions to reduce catheter-related bloodstream infection in hemodialysis patients. Clin J Am Soc Nephrol 9: 1232–1239, 2014).

Even though the emergence of resistance is not a major concern with nonantibiotic antimicrobial locks, the use of these compounds is associated with their own problems. Serious concerns have been raised regarding the safety of ethanol because it can be absorbed and enter the systemic circulation. Moreover, there may still be concerns that ethanol at high concentrations may have an effect on catheter material; therefore, its use is not routinely recommended (32). Similarly, citrate may leak from the catheter and produce significant ionized hypocalcemia and other signs of citrate toxicity (37).

In summary, there is potential for using nonantibiotic AMLs to decrease the rate of CRBSIs. However, the risk of systemic toxicity from these compounds is not inconsequential. Therefore, adequately powered multicenter prospective randomized clinical trials regarding the safety and efficacy of these compounds compared with existing best practices are required before promoting their widespread use.

Recently, the use of special central venous catheter caps with a chlorhexidine gluconate–coated rod (ClearGuard HD; Pursuit Vascular Inc.; Minneapolis,

Table 11. Summary of studies using nonantibiotic antimicrobial locks

Study	Study Type	Number of Patients	Catheter-days	Nonantibiotic Lock Solution vs. Control	Catheter-related bloodstream infection rates (antimicrobial locks vs. control)
Murray et al., 2014	Observational prospective	565	135,446	1.35% taurolidine, 4% citrate, and 500 IU/ml heparin vs. 5000 IU/ml heparin	0.69 vs. 1.59 per 1000 catheter-days, $P=0.004$
Solomon et al., 2010	Randomized controlled trial	110	17,771	1.35% taurolidine, 4% citrate vs. 5000 IU/ml heparin	1.4 vs. 2.4 per 1000 catheter-days, $P=0.1$
Winicki et al., 2017	Randomized controlled trial	106	15,690	1.35% taurolidine, 4% citrate + heparin 500 IU/urokinase 25,000 IU vs. 4% citrate	0.6 vs. 2.7 per 1000 catheter-days
Vercaigne et al., 2015	Randomized controlled trial, pilot	40	N/A	30% ethanol + 4% citrate vs. 1000 IU/ml heparin	0 vs. 0.75 per 1000 catheter-days
Winnett et al., 2008	Observational prospective	206	37,492	46.7% trisodium citrate vs. 5000 IU/ml heparin	0.81 vs. 2.13 per 1000 catheter-days, $P<0.0001$
Power et al., 2009	Randomized controlled trial	232	N/A	46.7% trisodium citrate vs. 5000 IU/ml heparin	0.7 vs. 0.7 per 1000 catheter-days
Maki et al., 2011	Randomized controlled trial	407	49,565	7% citrate + 0.05% methylene blue + 0.15% methylparaben + 0.015% propylparaben vs. 5000 IU/ml heparin	0.24 vs .0.82 per 1000 catheter-days, $P=0.04$

Original table summarized from references 27 (Murray EC, Deighan C, Geddes C, Thomson PC: Taurolidine-citrate-heparin catheter lock solution reduces staphylococcal bacteraemia rates in haemodialysis patients. QJM 107: 995–1000, 2014), 33 (Solomon LR, Cheesbrough JS, Ebah L, Al-Sayed T, Heap M, Millband N, et al: A randomized double-blind controlled trial of taurolidine-citrate catheter locks for the prevention of bacteremia in patients treated with hemodialysis. Am J Kidney Dis 55: 1060–1068, 2010), 34 (Winnicki W, Herkner H, Lorenz M, Handisurya A, Kikić Ž, Bielesz B, et al: Taurolidine-based catheter lock regimen significantly reduces overall costs, infection, and dysfunction rates of tunneled hemodialysis catheters. Kidney Int 93: 753–760, 2018), 35 (Vercaigne LM, Allan DR, Armstrong SW, Zacharias JM, Miller LM: An ethanol/sodium citrate locking solution compared to heparin to prevent hemodialysis catheter-related infections: a randomized pilot study. J Vasc Access 17: 55–62, 2016), 36 (Winnett G, Nolan J, Miller M, Ashman N: Trisodium citrate 46.7% selectively and safely reduces staphylococcal catheter-related bacteraemia. Nephrol Dial Transplant 23: 3592–3598, 2008), 37 (Power A, Duncan N, Singh SK, Brown W, Dalby E, Edwards C, et al: Sodium citrate versus heparin catheter locks for cuffed central venous catheters: a single-center randomized controlled trial. Am J Kidney Dis 53: 1034–1041, 2009), and 29 (Maki DG, Ash SR, Winger RK, Lavin P; AZEPTIC Trial Investigators: A novel antimicrobial and antithrombotic lock solution for hemodialysis catheters: a multi-center, controlled, randomized trial. Crit Care Med 39: 613–620, 2011).

N/A, not available.

MN) was granted 510K approval by the FDA for use as substantial equivalents to other catheter caps (38). The rod extends into the catheter hub, and the dry chlorhexidine coating is "activated" on contact with the catheter locking solution between the catheter hub and the proximal clamp. Its release into the catheter lumen kills the majority of the common pathogenic bacteria (38). The chlorhexidine also decreases colonization of the CVC hub. Inasmuch as chlorhexidine is an antibiotic-free antimicrobial, the risk of bacterial resistance is quite low. The ClearGuard HD caps underwent subsequent testing for efficacy (3,4).

The first prospective multicenter randomized trial of 2470 patients with 350,000 catheter-days showed that the use of ClearGuard HD caps for 12 months was associated with a 56% lower BSI compared with standard HD catheter caps (0.26 versus 0.59/1000 catheter-days). The sustained use of these caps for more than 6 months was associated with 43% fewer (0.28 versus 0.48/1000 catheter-days) CRBSI-related hospitalizations (3). The second trial compared the use of ClearGuard with Tego needle-free hemodialysis connectors (Victus; Miami, FL) plus Curos Disinfecting Port Protectors (70% isopropanol; 3M; St. Paul, MN) in 1671 patients for over 183,000 catheter-days

(4). The study showed a significantly lower BSI rate in the ClearGuard HD caps group (0.28 versus 0.75 per 1000 catheter-days, $P=0.001$). Both studies did not report any device-related side effects. Likely, the most significant impediment to future widespread use of this device is cost.

Routine use of the buttonhole technique has been associated with increased risk of infection. Proper central venous catheter care is essential if it is used as a hemodialysis access. Recent data show that central venous catheter caps with chlorhexidine-coated rods decrease the risk of blood stream infections compared with standard caps or isopropanol-containing caps.

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Hepatitis B in Hemodialysis Patients

The rate of new hepatitis B virus (HBV) infections in the United States has declined from 2000 to 2012. The decline has been greatest among children born since 1991, when routine vaccination of infants was initially recommended. Since a zenith of 8036 cases in 2000, there has been no consistent trend in acute HBV cases since 2012. Essentially, reported cases have fluctuated about 3000 cases annually. In 2016, 3218 cases were reported to the CDC (1). In the dialysis population, HBV has been recognized as a significant problem, although the last reported prevalence was approximately 1% for 2002 (2).

The diagnosis of HBV infection is based on testing for hepatitis B surface antigen (HBsAg), hepatitis B surface antigen antibody (anti-HBs), hepatitis B core immunoglobulin M antibody (IgM anti-HBc), and total hepatitis B core antibody (total anti-HBc). Testing may include antibodies to HBV DNA. These tests can imply acute or chronic infection or can represent natural or acquired immunity. Other HBV tests, including hepatitis B e antigen (HBeAg) and hepatitis B e antibody (anti-HBe), serve as surrogate markers for viral replication and infectivity and assist in making decisions regarding treatment (3,4). The interpretations of these tests may be challenging and are summarized in Table 12. In cases where HBsAg is negative but the clinical suspicion of infection is high, a test for HBV DNA should be performed (2,5).

Viral outbreaks in HD units have been linked to a lack of initial or recommended periodic screening, cross-contamination between patients as a result of poor cleaning and disinfection practices, suboptimal injection safety practices, or staff members who simultaneously care for both HBV-infected and susceptible patients. A list of risk factors appears below. Serologic testing for HBV infection with HBsAg, total anti-HBc, and anti-HBs is the standard of care for patients initiating HD, according to the CDC recommendations (6,7). Frequent serologic testing for HBsAg of susceptible patients detects HBV infection rapidly, and isolation procedures can be implemented before transmission can occur. For patients transferred from another unit, test results for HBV serologies should be obtained at the time of patient transfer. If an individual's serologic status is unknown at the time of admission, testing should be performed within 7 days. Furthermore, the staff working in the dialysis unit who are regularly exposed to blood and other body fluids should have documentation of a complete vaccine series with anti-HBs >10 mIU/ml at 1 to 2 months after vaccination. If these data are not readily available, staff should undergo vaccination and testing according to the CDC recommendations (available at https://www.cdc.gov/mmwr/volumes/67/rr/pdfs/rr6701-H.pdf). Listed below is the schedule for ongoing hepatitis B screening guidelines (Table 13).

HBV is transmitted through exposure to infectious blood or body fluids or by direct contact with mucous membranes (8). Moreover, HBV at high titers can exist on contaminated environmental surfaces without any visible blood for up to 7 days, and still be transmitted from these surfaces, attributable to the hardiness of DNA (9). Whereas some HD patients might have acquired the infection before starting HD, nosocomial transmission in dialysis units remains a concern. Some of the risk factors

Table 12. Interpretation of hepatitis B serology results

HbsAg	Anti-HBs	IgM Anti-HBc	Total Anti-HBc	Interpretation	Notes
Negative	Negative	Negative	Negative	No exposure	Susceptible to infection; needs vaccination
Negative	Positive	Negative	Negative	Successful vaccination	Patient has acquired immunity
Negative	Positive	Negative	Positive	Previous infection (now cleared)	Patient has natural immunity
Positive[a]	Negative	Negative	Negative	Early infection (first 2–4 weeks) or false positive	Patient is infective
Positive	Negative	Positive	Positive	Acute infection	Patient is infective
Positive	Negative	Negative	Positive	Chronic infection	Patient is infective
Negative	Negative	Negative or positive	Positive	Four possibilities: 1. Resolved infection with loss of antibody (most common) 2. False-positive anti-HBc, thus susceptible 3. "Low-level" chronic infection 4. Resolving acute infection	Interpretation unclear

[a]Recent exposure to vaccine may result in a positive Hbs Ag test that is detectable for approximately 4 weeks after vaccination (see reference 37, Power A, Duncan N, Singh SK, Brown W, Dalby E, Edwards C, Lynch K, Prout V, Cairns T, Griffith M, McLean A, Palmer A, Taube D: Sodium citrate versus heparin catheter locks for cuffed central venous catheters: a single-center randomized controlled trial. *Am J Kidney Dis* 53 :1034-41, 2009).

HBsAg, hepatitis B surface antigen; anti-HBs, hepatitis B surface antigen antibody; IgM anti-HBc, hepatitis B core immunoglobulin M antibody; total anti-HBc, total hepatitis B core antibody.

Original table created by Dr. Sana Waheed, University of Wisconsin School of Medicine and Public Health (Madison, WI)

for transmission of hepatitis B in a dialysis unit include the following:

1. A low rate of hepatitis B vaccination.
2. Lack of dedicated hemodialysis machines for patients who are positive for hepatitis B surface antigen (HBsAg).
3. Preparation of medications in the treatment area rather than a dedicated medication room.
4. Multiple-dose medication vials and intravenous solutions that were not used exclusively for one patient, and/or were prepared in areas adjacent to locations where blood samples were handled.
5. Staff members who simultaneously cared for both HBV-infected and HIV-susceptible patients.
6. Contaminated environmental surfaces or supplies:
   a. environmental surfaces, supplies (*e.g.*, hemostats, clamps), or
   b. equipment that was not routinely disinfected after each use.

Therefore, adherence to precautionary measures against transmission is imperative in HD units.

Table 13. Screening guidelines for hemodialysis patients

Patient Characteristic	Serology at Baseline	Screening Recommendation
Susceptible to hepatitis B infection[a]	Negative HBsAg and negative anti-HBs	Monthly screening with HBsAg only (50,51)
Immune from a prior vaccination	Anti-HBs ≥10 IU/ml	Annual screening with anti-HBs and booster if titer <10 IU/ml
Immune from a prior infection[b]	Anti-HBs ≥10 IU/ml and anti HBc positive	No further testing required

Table created by Sana Waheed, M.D., University of Wisconsin School of Medicine and Public Health (Madison, WI)

[a]Susceptible persons should have vaccination; however, vaccine non-responders remain susceptible and should undergo monthly screening;

[b]Some immune-compromised (*e.g.*, HIV or chemotherapy-related) patients may be at risk for reactivation, and although no evidence-based guidelines exist, liver function tests (an increase may indicate an acute flare, with or without symptoms) or HBsAg testing (reappearance indicates reactivation), or HBV DNA levels could be monitored.

HBsAg, hepatitis B surface antigen; anti-HBs, hepatitis B surface antigen antibody.

These measures include standard procedures to prevent exposure to blood-borne microorganisms discussed previously and the appropriate steps to address risk factors noted above.

HBV vaccination of susceptible patients and staff and treatment of HBV-infected individuals in the dialysis unit can decrease transmission risk significantly, too (6). Patients are more likely to respond to vaccinations when they are administered before the initiation of dialysis. If a patient is vaccinated after initiation of dialysis, a higher dose is recommended (10). HBV vaccination doses for adults with CKD (without transplants) are shown in Table 14 (11–13). In pediatric patients, protective levels of antibody occur in 75% to 97% of those who receive higher dosages (20 μg) on either a three-dose or a four-dose schedule (14–17). Although pediatric patients may benefit from an augmented dose of HBV vaccine, current recommendations are that pediatric dialysis patients receive immunization with the standard dose.

After 1 to 2 months after completion of an HBV vaccination series, patients should be tested for anti-HBs. If not immune, patients should undergo readministration of the HBV series. Nonresponders to a second series are considered HBV susceptible and do not require further attempts at immunization. Monthly testing for HbsAg is recommended for nonresponders. Vaccinated HD patients who demonstrate immunity require annual ant-HBs testing. A booster dose should be administered when anti-HBs levels decline to <10 mIU/ml.

Dialysis unit staff should have evidence of a full course of vaccination against HBV using the standard dose and an antibody level ≥10 mIU/ml 1 to 2 months after completion of an HBV vaccination series. Staff who do not have such documentation should be revaccinated and tested according to the CDC guidance (https://www.cdc.gov/mmwr/volumes/67/rr/pdfs/rr6701-H.pdf).

Dialysis patients with chronic HBV infection should be evaluated and monitored indefinitely by a physician experienced in HBV evaluation, treatment, and monitoring. Liver evaluation by markers of fibrosis or biopsy may be helpful. HBV viremia can be controlled with treatment, decreasing liver inflammation and fibrosis. However, loss of surface antigen is less easily achieved. The optimal HBV infection treatment regimen for dialysis patients is unclear; however, interferon-α, nucleoside, and nucleotide analogues are all potential options (12). Patients with fibrosis should be monitored twice yearly for development of hepatocellular carcinoma.

Patients with active HBV infection should receive dialysis in an isolation room. If an isolation room is used by a patient with HBV, it should not be used for any HBV-negative patients.

Patients who are susceptible to hepatitis B infection should be screened with monthly hepatitis B surface antigen testing. Although most patients eventually respond to vaccination, some patients are classified as nonresponders and remain hepatitis B virus susceptible.

Table 14. Adult vaccination schedule for hepatitis B

Vaccination Type	Dose (Nondialysis Patients)	Schedule (Nondialysis Patients)	Dose (Dialysis Patients)	Schedule (Dialysis Patients)
Engerix	20 μg	Three doses at 0, 1, and 6 months	40 μg	Four doses at 0, 1, 2, and 6 months in dialysis dependent patients)
Recombivax	10 μg	Three doses at 0, 1, and 6 months	40 μg (dialysis formulation)	Three doses at 0, 1, and 6 months
Heplisav	20 μg (plus adjuvant)[a]	Two doses at 0 and 1 month	No data in dialysis patients	No data in dialysis patients

[a]Adjuvanted with toll-like receptor 9 – CpG oligodeoxynucleotide (Dynavax Technologies Corporation, Dusseldorf, Germany); approved in 2017 by the U.S. Food and Drug Administration for adults. Determined equivalent with fewer doses, immunogenic in nonresponders to standard vaccine.

Table created by Sana Waheed, M.D., University of Wisconsin School of Medicine and Public Health (Madison, WI) using reference 52 (Guidelines for Vaccinating Kidney Dialysis Patients and Patients with Chronic Kidney Disease, 2012; https://www.cdc.gov/vaccines/pubs/downloads/dialysis-guide-2012.pdf (Accessed June 20, 2018).

Hepatitis C Virus Infection in Hemodialysis Patients

In the United States population, reported cases of acute hepatitis C virus (HCV) infection increased nearly 3.5-fold from 2010 through 2016 (from 850 to 2967 reported cases), increasing annually during this period (Figure 12) (1). According to annual trends beginning in 2012, reported cases of acute HCV infection increased by 20.2% from 2012 to 2013 (n=1778 and 2,138 cases, respectively), by 2.6% to 2194 cases in 2014, by 11.0% to 2436 cases in 2015, and by 21.8% to 2967 cases in 2016.

It became rapidly apparent after HCV diagnostic testing was introduced that patients receiving maintenance hemodialysis (MHD) had a high prevalence of HCV infection and furthermore that HCV acquisition was occurring in the outpatient dialysis setting. Despite screening of blood products, HCV infection has remained highly prevalent in the MHD population (18). In a multinational study in the period 1996–2002, the prevalence of HCV in HD patients in the United States was 7.4% (19). A recent update from the period 2012–2015 indicates that the HCV prevalence in MHD patients in the United States is 6.9% (20).

The data imply that among a dialysis population in the Unites States of approximately 450,000 patients, there may be 30,000 HCV-infected MHD patients.

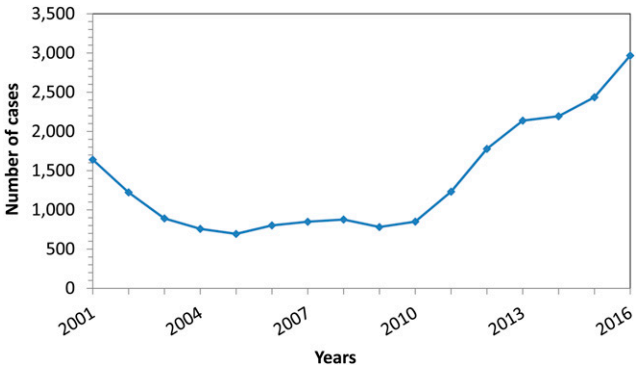

Figure 12. Rising incidence of acute hepatitis C virus infections tracked by the Centers for Disease Control. The number of reported acute hepatitis C cases declined 48.2%, from 1640 in 2001 to 850 in 2010. The rate then increased 3.5-fold to 2967 cases in 2016. From 2015 through 2016, the number of acute HCV cases increased 21.8% (from 2436 to 2967 cases). Reprinted from reference 1 (Centers for Disease Control and Prevention (CDC): Surveillance for viral hepatitis – United States, 2016. Available at https://www.cdc.gov/hepatitis/statistics/2016surveillance/commentary.htm).

Despite effective strategies to limit the spread of HCV among MHD patients (21), HCV acquisition confirmed by phylogenetic analysis is ongoing and typically reflects a lack of attention to basic infection prevention measures, including not sharing medication vials between patients, hand hygiene, glove use, cleaning and disinfection, and separation of clean from dirty items (22). The CDC has been informed that approximately 36 cases of acute HCV in MHD patients occurred from 2014 to 2015. Consequently, the CDC issued an alert that stressed adherence to precaution measures that prevent HCV transmission in HD units (23). Transmission of infection can be limited by adherence to recommended infection control practices, including the following:

1. Good injection safety and medication preparation
2. Environmental cleaning and disinfection practices
3. Good hand hygiene and glove use
4. Adherence to aseptic technique during vascular access

In the general population, efforts to identify HCV-infected patients have typically focused on individuals with acknowledged risk factors for HCV infection, including intravenous drug use and receipt of blood transfusions before 1992 (24). HD patients were included in this high-risk group, reflecting the high prevalence of HCV in this population. Medicare covers a screening test for adults at high risk for HCV, defined as persons with a current or past history of illicit injection drug use or persons who have a history of receiving a blood transfusion before 1992. Repeated screening for high-risk persons is covered annually only for persons who have had continued illicit injection drug use since the prior negative screening test result. Additionally, a single screening test is covered for persons born between 1945 and 1965 because this birth cohort has a relatively high prevalence of HCV infection (25). For outpatient HD facilities, HCV testing is recommended as part of the work-up at entry and every 6 months in patients receiving MHD (23,26). However, the CMS does not reimburse routine screening tests for patients with ESRD and excludes the HCV screening requirement from the Conditions for Coverage [42 CFR 494.30(a) (1)(i)], with guidance for Medicare-covered HCV-testing contingent on an elevated alanine aminotransferase test result (27). Therefore, whereas monthly screening of alanine aminotransferase

is covered, care providers are left with the financial burden of HCV screening in MHD patients if screening is pursued.

For an HCV-infected CKD patient, there are several important consequences of infection, including increased mortality (28,29). Cirrhosis and hepatocellular cancer have been implicated in this excess mortality. Another important consequence of HCV infection for a patient with CKD is the effect on potential candidacy for kidney transplantation. HCV infection has been shown to diminish graft and recipient survival after kidney transplantation (29). HCV-infected kidney transplant candidates with cirrhosis or focal hepatocellular cancer may not be eligible for isolated kidney transplants and may require consideration for combined liver-kidney transplantation, a far more extensive procedure. There is increasing evidence that HCV infection not only causes renal disease, often mediated by cryoglobulinemia, but accelerates the progression of CKD in general (30).

Until recently, options to treat HCV infection were limited by poor tolerability and efficacy. However, several efficacious regimens using direct-acting agents are now available to treat HCV infection in patients with CKD, including patients receiving dialysis (31–33). However, owing to the rapid accumulation of data and evolving evidence, it will be best to review updated details of treatment regimens at https://www.hcvguidelines.org/unique-populations/renal-impairment for newer combinations as they emerge. Earlier identification of HCV-infected CKD patients will allow access to effective antiviral therapy that has already demonstrated favorable outcomes in successfully treated patients, with reduction in all-cause mortality (34). The cost effectiveness of HCV treatment in patients receiving renal replacement therapy with no reasonable chance for kidney transplantation has not been determined. However, future eradication of HCV infection in the CKD and ESRD populations will be facilitated by reducing its prevalence with direct-acting antiviral therapy. Identification of HCV infection through screening of patients presenting with renal dysfunction, including renal transplantation candidates, and control of spread within the dialysis population not only will contain the spread of HCV infection but, in combination with effective antiviral therapy, will mitigate the effects of infection on patients' liver disease, native kidneys, or renal allografts.

Hepatitis C virus acquisition continues to occur in hemodialysis units because of a lack of adherence to recommended infection control practices. Acute infection is typically subclinical. The evidence of initial acquisition may be a modest rise in aminotransferases before hepatitis C virus seroconversion, which is frequently delayed for several months after infection. Various other adverse outcomes in this population include diminished allograft and recipient survival after kidney transplantation. The new direct-acting antiviral regimens can cure hepatitis C virus infections in patients with chronic kidney disease as well as in renal transplant recipients.

Human Immunodeficiency Virus Infection in Hemodialysis Patients

Outbreaks of human immunodeficiency virus (HIV) infections in HD units have not been reported in the United States. However, HIV outbreaks linked to breaches in infection control practices, including improper disinfection of patient care equipment such as vascular access needles, use of contaminated/soiled gloves, and use of multidose heparin vials, have been reported in at least three countries outside the United States (35–37).

HIV screening is recommended for all patients aged 13 to 64 years in all healthcare settings (38). However, this is not a CDC recommendation for purposes of infection control. Clinicians should test patients who have clinical signs of HIV infection and opportunistic infection(s) or a clinical syndrome of acute HIV (39). Nephrologists who are not comfortable managing cases of HIV must ensure that patients suspected of having HIV are screened and/or treated by their primary care physician or infectious disease specialist.

HIV testing must be voluntary and free of coercion and must not be done without the patient's knowledge (39). If the nephrologist wants to test for HIV, patients should be informed of testing and provided with information on the meaning of positive and negative test results. Patients should have an opportunity to ask questions and to decline testing. HIV

screening should be incorporated into the patient's general informed consent for medical care on the same basis as are other screening or diagnostic tests. A separate consent form for HIV testing is not recommended.

Recommended initial testing for HIV is an FDA-approved test that can detect HIV-1, HIV-2 antibodies, and HIV-1 p24 antigen (40). No further testing is required for specimens that are nonreactive. For specimens found to be reactive, confirmatory testing should be done on an FDA-approved assay that differentiates HIV-1 from HIV-2. Nucleic acid testing should be performed on specimens reactive on the initial HIV-1 and HIV-2 antibody/antigen test and nonreactive on an HIV-1 and HIV-2 differentiation assay.

HIV-infected patients in HD units do not require isolation from other patients or dedicated staff or equipment. Standard infection control precautions recommended for all HD patients should prevent patient-to-patient transmission of HIV (6). Patients who are found to be HIV-infected on screening should be referred for counseling and treatment.

Mycobacterium Tuberculosis in Hemodialysis Patients

The presentation of tuberculosis (TB) in maintenance HD patients is often protean, with pulmonary symptoms in about 50% of patients; others experience fever of undefined origin, chest wall or node masses (scrofula), peritonitis, osteomyelitis, intra-abdominal infection manifesting as abdominal mass, enlarged lymph nodes, hepatitis, or pancreatic lesions (31). In the United States, risk factors for TB in patients receiving long-term HD are older age, native American heritage, Asian heritage, immigration from endemic nations, poor socioeconomic status, poor nutrition (low serum albumin), illicit drug use, and residence in the Southern states (32,35). In a study of United States patients who initiated dialysis from 1995 to 1999, the incidence of TB was 0.8% per year (overall) with a cumulative incidence of 1.2% for peritoneal dialysis and 1.6% for HD patients. Although rare, transmission of TB has been reported in HD centers (41,42)

There is no national or international consensus regarding the best screening tests for *Mycobacterium tuberculosis* in chronic dialysis patients. In the United States, the CDC currently recommends either a tuberculosis skin test (TST) or a blood test for screening of TB infection. For dialysis patients, screening should be done upon admission to the dialysis clinic. A Mantoux TST consists of 5 units injected intracutaneously, with palpable induration read 48 hours later. For dialysis patients, a positive test result is a papule $\geq$10 mm in diameter. However, anergy is common in dialysis patients, and up to 40% of patients have no response to either *Candida* or mumps antigen skin testing. In that setting, a TST may be falsely negative. Using a 10-unit Mantoux TST can increase the sensitivity of the TST (43). Prior immunization with Bacillus Calmette-Guérin (BCG) may lead to false TST positivity in patients without latent or active TB (44). Reactions of $>$20 mm of induration are not likely caused by BCG. A positive reaction to tuberculin in BCG-vaccinated persons at increased risk for recent infection (*e.g.*, exposure) or with medical conditions that increase disease risk indicates TB infection until proved otherwise.

Two new measurements of interferon-γ release induced by TB-specific proteins can increase the sensitivity of TB screening in patients receiving long-term dialysis patients. In the T-Spot TB test, the TB-specific proteins ESAT-6 and CFP-10 are incubated with the patient's mononuclear leukocytes, and subsequent interferon-γ release produces quantifiable spots (45). In the QuantiFERON-TB Gold assay, these proteins induce interferon-γ quantitated by enzyme-linked immunosorbent assays (48). This test requires a special kit for handling and shipping, thereby making it more difficult and expensive to obtain. Both tests have been used as screens for active and latent TB in patients receiving long-term dialysis (46). They are 905 to 100% sensitive for the identification of active TB in patients receiving long-term dialysis. The tests have a sensitivity of 46% to 78% for the identification of latent TB (Table 15). There is no consensus preference for either of these assays (47).

The 10-unit Mantoux TB skin test is the initial screen commonly used in patients initiating maintenance dialysis without clinical evidence of active TB infection. Although this practice remains acceptable, a joint panel from the American Thoracic Society, Infectious Diseases Society of America, and CDC developed guidelines (48,49) that suggest an interferon-γ assay (not specific to Tspot TB or QuantiFERON–Gold) as the preferred test in patients with high risk for latent TB infection (*e.g.*, immigrant from an endemic location) in a low-risk or intermediate-risk category for progression (*i.e.*, inclusive of chronic renal failure). TST is also an acceptable alternative. If the skin test result (or interferon- γ assay result) is positive,

Table 15. Summary of studies on the value of interferon-γ release assays for the diagnosis of *Mycobacterium tuberculosis* in ESRD patients

Study	*N*	Objective	IGRA	Sensitivity (%)	Specificity (%)	Indeterminate Results (%)
Inoue et al. (53)	162 HD	Diagnosis of active TB	QFT-G	100	89.7	24.1
Zoccali et al. (54)	29 HD	Diagnosis of active TB	T-SPOT.TB	91.7	64.7	NA
Passalent et al. (55)	203 HD	Diagnosis of LTBI	T-SPOT.TB	73.1 to 78.6	NA	5.1
Triverio et al. (56)	62 HD	Diagnosis of LTBI	T-SPOT.TB	22	61.2	11.0
			QFT-G	46	75.5	8.0
Chung et al. (48)	167 HD	Diagnosis of LTBI	T-SPOT.TB	65.7	41.9	4.8
			QFT-G	62.5	63.5	12.6
Hoffmann et al. (57)	39 HD	Diagnosis of LTBI	QFT-GIT	71.4	100	2.6

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HD, hemodialysis; LTBI, latent tuberculosis infection; TB, tuberculosis; QFT-G, QuantiFERON–GOLD; IGRA, interferon-γ release assay; QFT-GIT, QuantiFERON-TB Gold In-Tube test.

then a chest radiograph is obtained, and the patient is evaluated for TB disease (available at: https://www.cdc.gov/tb/topic/testing/diagnosingltbi.htm).

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Multidrug-Resistant Organisms in Hemodialysis Patients

Antimicrobial therapy for HD-associated infections has contributed to the prevalence of multidrug-resistant organisms (MDROs) based on an analysis of the CDC's Active Bacterial Core surveillance system (1). MDROs, "defined as microorganisms, predominantly bacteria, that are resistant to 1 or more classes of antimicrobial agents" (2), are a serious public health threat (3,4). Methicillin-resistant *S. aureus* (MRSA), vancomycin-intermediate *S. aureus* (VISA), vancomycin-resistant *S. aureus* (VRSA), vancomycin-resistant enterococcus species (VRE), and certain gram-negative bacteria (GNB), including those producing extended spectrum β-lactamases (ESBLS) and carbapenemases, are examples of MDROs (5).

MDROs are significant because antimicrobial options to treat patients with MDRO infections are often limited. Additionally, some MDROs that spread easily are public health and clinical concerns and are targeted for aggressive interventions (6). MDRO infections are also associated with increased length of hospital stay, costs, and mortality (2). HD patients are particularly vulnerable to infections with MDROs because of their exposure to healthcare settings, need for invasive medical procedures, and exposure to antibiotics (1). HD patients were found to have a 40-fold to100-fold higher risk of MRSA infection than the general population (1,7).

Vancomycin-resistant staphylococci and enterococci have been reported in HD patients. In the 1980s, one of the first cases of VRE was reported by a renal unit in England; more recently, there were four HD patients among the first 14 patients in the United States identified with VRSA (8,9). In 2014, antimicrobial susceptibility results of isolates from BSIs reported by outpatient HD clinics in the United States revealed that 40% of *S. aureus* were methicillin-resistant, 11% of *Enterococcus* species were vancomycin-resistant, 18% of *Escherichia coli* were resistant to third-generation cephalosporins, and 15% of *Klebsiella* species were resistant to cephalosporins (10).

Patients can be colonized (*i.e.*, microorganisms are present with no clinical signs of infection) or infected with an MDRO. Colonization with MRSA or VRE was associated with a higher risk for the development of severe infections in dialysis patients (6). One approach to reducing this risk is decolonization, which "entails treatment in a patient colonized with a specific MDRO to eradicate carriage of the organism" (2). However, there is limited evidence for the value of decolonization therapy in dialysis settings. Furthermore, decolonization is not necessarily an option for all MDROs.

Dialysis patients colonized or infected with MDROs can serve as a source of transmission in outpatient dialysis clinics (8). Patient-to-patient transmission of MDROs occurs in the same fashion as for antimicrobial-susceptible organisms, predominantly by the hands of healthcare workers. Preventing the spread of MDROs requires a comprehensive approach, including timely diagnosis and appropriate treatment of infections, judicious and appropriate use of antibiotics, and prevention of microorganism transmission in the dialysis setting through strict adherence to infection control measures such as hand hygiene and environmental cleaning (2). Cleaning and disinfection of dialysis stations used by patients with MDROs should follow standard environmental cleaning, with attention to appropriate choice of disinfectants (*e.g.*, specific for infections such as *C. difficile*), as recommended for all HD stations (2).

Standard infection control practices in HD units are presumed adequate to prevent transmission of MDROs (8). However, additional precautions should be considered in patients with increased risk of transmission of MDROs based on their clinical presentation. This includes patients with the following:

1. Uncontrollable wound drainage(s) that cannot be contained by dressings
2. Fecal incontinence or uncontrolled diarrhea
3. Other bodily discharges that might increase the potential risk for extensive environmental contamination
4. Infection or colonization with certain MDROs that have been targeted by public health authorities for aggressive control measures such as VRSA may also warrant additional infection control precautions because of the threat to public health, if these MDROs were to become widespread.

For these patients, the following additional precautions should be used (9,11):

1. Disposable gown and disposable gloves must be worn by staff while caring for the patient or touching equipment at the patient station. The gown should be removed and disposed of, and hand hygiene should be performed before leaving the patient's station.

2. Administer dialysis to the patient in a separate room, not used for patients on hepatitis B virus isolation precautions, if available. If a separate room is not available, administer dialysis in a section of the dialysis unit with as few adjacent stations as possible (*e.g.*, end of a row).
3. Items brought into the dialysis station should be disinfected before they are removed or discarded, if they cannot be disinfected.

Overall, infection prevention and control in outpatient HD units requires vigilance and preparedness to meet the looming challenge of MDRO development and containment. Education and communication regarding the latest updates and coordination among clinical staff and between clinical staff and external parties such as public health experts or family and community stakeholders is essential. Within the dialysis facility, all appropriate personnel should be informed of the presence of any patient with a high concern for MDROs and pertinent precautions. If needed, report documented cases of MDROs to your local health department and/or the CDC. Finally, if a patient is admitted to or referred from another facility, it is important to communicate and inform the referring or receiving facility that the patient may be colonized or infected by an MDRO in a timely manner, which facilitates the exercise of necessary precautions by these parties. The Medical Director, admitting nephrologists, and nursing staff should establish communication processes/protocols with referral institutions that specifically include MDRO status in addition to other medical and clinical information. Keep in mind that the outpatient HD facility is part of the larger healthcare system and society, with a responsibility to contribute its share in addressing the MDRO challenge.

Antibiotic Stewardship in Hemodialysis Patients

In the United States, approximately 30% of patients undergoing long-term HD receive at least one dose of antibiotics in a given year (12). Vancomycin is the most commonly prescribed antibiotic, followed by cefazolin and then a third- or fourth-generation cephalosporin (13). Antibiotics have contributed significantly to the survival of patients with infections and sepsis (14). However, antibiotic use is associated with adverse drug events and the emergence of MDROs, and it is a risk factor for acquiring C difficile infections (1,5,15,16). Inappropriate antibiotic use contributes to these serious public health threats and exposes patients unnecessarily to other adverse effects of antibiotics without any clinical benefit (15). Based on limited data, it is estimated that inappropriate antibiotic use accounts for 30% of antibiotic prescriptions in outpatient HD clinics (13).

Antibiotic stewardship aims at improving patient outcomes and safety by optimizing antibiotic use, improving infection cure rates, and decreasing unnecessary and inappropriate antibiotic use (15). It is fundamentally a patient safety issue and a prevention strategy for antimicrobial resistance. In hospital settings, antibiotic stewardship programs have been effective in improving antimicrobial use, with the additional benefit of cost savings related to decreasing unnecessary antibiotic use (12). Monitoring and evaluating antibiotic use in individual HD clinics can inform strategies to improve and optimize antibiotic prescribing. Some aspects of antimicrobial use and stewardship in outpatient HD clinics that might benefit from increased attention and interventions include the following:

1. Obtaining blood cultures before initiating antibiotics for suspected BSIs (17)
    a. The Infectious Diseases Society of America recommends that blood for cultures be drawn before initiating antimicrobials when a BSI is suspected
    b. Appropriate procedure and technique should be used when collecting blood cultures. Failure to do this could lead to
    i. False-positive blood culture results, which may lead to unnecessary use of antibiotics
    ii. False-negative blood culture results, which may lead to failure to identify a BSI and premature discontinuation of antibiotics
2. Collecting blood culture results, including antimicrobial sensitivities from hospitals, after hospital discharges, and across transitions of care is important in selecting appropriate antibiotics and duration of treatment
3. Decreasing inappropriate antibiotic use by adjusting antibiotic therapy to be consistent with culture and sensitivity results
    a. Failure to select an appropriate narrow-spectrum antibiotic once blood culture results become available was identified as a category of inappropriate use (13)
    i. Vancomycin was the most commonly inappropriately prescribed antibiotic, followed by

third-generation cephalosporins. Beta-lactam antibiotics should be selected over vancomycin when appropriate. For infections with methicillin-sensitive *S. aureus*, treatment with nafcillin and cefazolin was associated with better outcomes than vancomycin, and this strategy was also demonstrated in outpatient HD patients (18)

ii. Similarly, a narrower-spectrum cephalosporin (first-generation) should be selected over a third-generation cephalosporin when appropriate

b. Failure to meet indications and duration for surgical prophylaxis (13,16)

c. In one study, the most common reason for inappropriate antibiotic use was that infection criteria were not met based on national guidelines, *e.g.*, administering antibiotics for a single positive blood culture for coagulase-negative staphylococci in the absence of any clinical signs of infection, and skin and soft tissue infections (17)

There are currently no recommendations on antibiotic stewardship programs specific to outpatient HD units. The CDC core elements of antibiotic stewardship programs for hospital settings provide a framework for assessing current and new stewardship activities, and for monitoring and improving antibiotic use. The core elements have been adapted to different healthcare settings, including small and critical access hospitals, nursing homes, and outpatient facilities. The core elements of hospital antibiotic stewardship programs include the following: leadership commitment, accountability and drug expertise, implementation of policies and interventions to improve antibiotic use, tracking and reporting antibiotic use and outcomes, and education. Additional evidence may be needed to determine those elements that are feasible and effective in outpatient HD settings (available at: https://www.cdc.gov/antibiotic-use/health care/implementation/core-elements-small-critical.html; https://www.cdc.gov/longtermcare/prevention/antibiotic-stewardship.html; https://www.cdc.gov/antibiotic-use/community/improving-prescribing/core-elements/core-outpatient-stewardship.html).

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Approach to Fever in the Hemodialysis Setting

Fever is a leading reason for presentation to emergency departments by ESRD patients receiving HD. In a recent retrospective review of HD patients in

Saipan (1), fully 50% of the total population of Saipan's HD patients presented to the sole Saipan emergency department at least one time with either subjective descriptions of fever or documented body temperatures ≥100.4°F during the study period of 2014 to 2017. HD patients made a total of 3424 visits, of which 358 (10.5%) visits primarily involved fever.

In the 353 of 358 visits in which the patients were thoroughly evaluated for sepsis, the sources of fever were determined as pulmonary (26%), urinary (17.8%), HD catheter-related (17.3%), skin and soft tissue infection (16.7%), viral infection (10.8%), and unknown origin (9.3%). Osteomyelitis and intra-abdominal infection occurred rarely. However, bacteremia occurred in 31.7% of these cases. Strong predictors/risks of bacteremia included the presence of an HD catheter, a prior history of bacteremia, and presence of bandemia. Fever as defined by this study with the presence of a HD catheter was associated with bacteremia in 53.6% of cases. Bacteremia occurred in only 15% of cases without catheters (1).

Numerous studies implicate HD catheters as a risk factor for bacteremia (2). The most recent United States Renal Data System data continue to support this association (3). A large seminal CDC study of HD adverse events reported that the risk of bacteremia associated with HD catheters was 27.7 BSIs per 100 patient-months for temporary catheters, 4.2 for permanent catheters, 0.9 for patients with arteriovenous grafts, and 0.45 for patients with arteriovenous fistulas (4). Therefore, fever and suspected bacteremia in a patient with an HD catheter incriminates the catheter as a primary suspected source until proven otherwise. On the other hand, maintenance HD patients with fistulas and possibly grafts who present with fever have a differential diagnosis that is similar to that in CKD patients who are not dialysis dependent. Other risk factors for HD patients, in addition to vascular access, may include low albumin, diabetes, and low hemoglobin levels (5).

Given the advanced age of many HD patients, the clinician must be aware that infections in older persons may be particularly challenging to diagnose and treat. To confound matters more, the clinical presentation of an infected older person may be relatively unimpressive despite the severity of infection. Older adults, especially frail individuals, can ill afford diagnostic delays, given the high morbidity and mortality rates for infectious diseases in this population. Diagnostic delays frequently occur because infections in older persons may present in nonclassical fashion (6,29). Nonclassical presentations in this population with chronic diseases may include worsening of baseline cognition and/or delirium, changes in functional activities of daily living, lethargy, anorexia, falls, autonomic dysfunction, and/or urinary incontinence. A summary of atypical presentations for some specific infections in older persons that may include maintenance dialysis patients is shown in Table 16.

Fever, the cardinal sign of infection, may be blunted, especially in frail elderly populations, and this may occur in up to one-third of older persons with serious or life-threatening infections. Conversely, fever, especially if ≥101°F (oral) in patients >80 years of age is overwhelmingly due to serious bacterial or fungal infections, and less often from viral illness (7). The accepted definition of fever in frail older persons is currently any oral temperature >100°F or persistent oral temperature >99°F. Given the close to 1°F decline in body temperature with age, a temperature >2°F over baseline would also be considered a fever (6). It is well established that the average HD patient's predialysis session body temperature is about 1°F lower than in non-HD patients,

Table 16. Atypical presentation of key specific infections in older persons

Bacteremia	May be afebrile or even hypothermic; clinical clues include hypotension, tachypnea and delirium.
Pneumonia	Cough, chest pain, sputum production, and fever may be absent or blunted. Tachypnea is an important clinical clue.
Urinary tract infection	Lower urinary tract symptoms may be absent with cystitis. Additionally, flank pain and tenderness may be absent in upper tract infection. In patients with residual urine formation, clinical clues include new onset of urinary incontinence, leaking around bladder catheter, or unexplained acute functional decline.
Intra-abdominal infection	Peritoneal signs may be blunted or absent. Anorexia may be the sole presenting symptom.

Original table: Courtesy of Dr. Dean Norman, University of California San Diego School of Medicine Division of Geriatrics and Gerontology (La Jolla, CA) and Dr. Thomas Yoshikawa, VA Greater Los Angeles Healthcare System and David Geffen School of Medicine at UCLA.

comparable to that of the elderly. Thus, even for the younger, more robust HD patient, a change in baseline temperature more than 2°F over baseline is significant. An absolute temperature of ≥100.4°F in an HD patient is considered a fever (1). Hence, it is important to interpret vital signs in the context of a person's historical baseline vital signs.

If the patient meets the criterion for fever and the index of suspicion for infection is high based on the above, then the responsible clinician should try to determine the source of the fever before considering transferring the patient to an emergency department unless the patient's condition is unstable. Preliminary data can be collected by the nurse(s) caring for the patient and relayed to the clinician responsible, if the clinician is not on site (8). This information should include, at minimum, the history and physical examination findings listed in Table 17.

In patients suspected of having an infection, particularly with a possibility of bacteremia, blood cultures should be obtained before initiating antibiotics (9), as

Table 17. Criteria for fever and suspicion for infection

History		Physical Examination Could Be done Nurse and relayed to Physician[a]
Symptoms	**Patient Factors**	
Timing of fever (low-grade noninfectious fevers may occur during dialysis but should resolve after treatment)	Vascular access (ask about pain, discharge, swelling; note that a CVC is a major risk factor for access site infection and bacteremia)	Vital signs (consider "rule of 100" for temperature, pulse, and blood pressure[b]); compare with historical baseline vital signs
Chills/rigor/sweats	Age-related risk factors	Assess cognition
Acute cognitive decline	Illicit drug use	Vascular access site(s) for redness, bleeding, swelling, purulent discharge
Acute functional decline (*i.e.*, ADLs[c])	Medications (*i.e.*, determine if truly taking[d])	
Classical symptoms • New onset of productive cough, chest pain and dyspnea indicating pneumonia; • Dysuria, frequency, urgency, cloudy urine or flank pain indicating possible symptomatic urinary tract infection; • Diarrhea, and if associated with recent antibiotic use, consider *Clostridium difficile* infection	Comorbidities • Vasculitis • Hepatitis C • HIV • Diabetic neuropathy • Past episode of bacteremia, urinary catheter, or intermittent bladder catheterization	Basic assessments • Check for rales or rhonchi/wheezes; • Inspect skin for lesions or signs of inflammation; • Inspect for infected pressure ulcers in immobile patients; • Inspect feet in insensate diabetic patients

CVC, central venous catheter; HIV, human immunodeficiency virus.

[a]A texted picture of any finding, within Health Insurance Portablity and Accountability Act guidelines, can be sent to the clinician for further analysis.

[b]The rule of "100" can be an early sign of infection/sepsis: temperature 100°F or more, pulse 100 beats per minute or more, systolic blood pressure <100 mm Hg or 20 mm Hg below baseline.

[c]ADL: activities of daily living to include: dressing, eating, ambulation, toileting and hygiene (bathing).

[d]For example, anticholinergic medications may result in delirium and increase the risk of pneumonia (19). Sedating medications such antipsychotic medications and narcotics increase the risk of aspiration and pneumonia.

Data compiled from reference 8 (Allon M: Treatment guidelines for dialysis catheter-related bacteremia: an update. *Am J Kidney Dis* 54: 13-7, 2009).

enumerated in the preceding "Antibiotic Stewardship" section. Frequently, antibiotics are administered to febrile HD patients without blood cultures. This practice exposes uninfected patients to unnecessary courses of antibiotics.

Additional laboratory testing may be required, but this does not substitute for sound clinical judgment. Point-of-care testing should include blood glucose and electrolytes, and, if feasible, a white blood cell count with differential count. A differential leukocyte count that reveals a left shift, especially with bandemia, is highly suggestive of a serious bacterial infection (10). Care must be taken to review medications, because concurrent intake of immunosuppressive agents (*e.g.*, for a prior transplant) will potentially blunt this finding. More comprehensive laboratory testing such as C-reactive protein, erythrocyte sedimentation rate, procalcitonin level, and serum lactate are often done during the inpatient setting or in the emergency department.

For patients with residual urine output, a urinalysis may be appropriate. The absence of pyuria strongly militates against symptomatic urinary tract infection. Procalcitonin levels in uninfected ESRD patients may reside at the upper limits of normal when compared with values obtained for uninfected patients not receiving dialysis. Therefore, the utility of measuring procalcitonin to help establish the diagnosis of severe infection in ESRD has not been determined. However, a low serum calcitonin in a patient with a borderline presentation for infection would militate against a bacterial infection. When fever and chills develop in multiple patients, consider the local water or dialysate source and perform endotoxin and dialysate cultures. In these circumstances, the Medical Director must determine whether dialysis treatments are stopped until further notice.

The decision to send an HD patient to an acute-care emergency department will depend on whether the source of a fever or functional decline is an infection with low risk of bacteremia (*e.g.*, cystitis, bronchitis, mild cellulitis). Robust patients who are reliable and have mild respiratory symptoms and clear respiratory examination results, and a borderline chest X-ray or good oxygenation on pulse oximetry, if available, may be considered for outpatient treatment with a course of oral antibiotics. However, tachypnea and shortness of breath if developing or already present in the setting of no overt fluid overload status is an indication to send the patient to the emergency department, where a chest radiograph should be obtained. It is often difficult to differentiate between fluid overload and pneumonic infiltrates, but the presence of fever, elevated white blood cell count, and elevated procalcitonin implicate pneumonia. The absence of an infiltrate virtually rules out pneumonia, with a negative predictive value of 81% in the study by Judd and colleagues (11). For suspected upper urinary tract infection or intra-abdominal infection, the emergency department workup should result in urgent ultrasonography and possibly computed tomography. Other than minor skin and soft tissue infections, especially if there are systemic signs of infection, the affected areas should minimally be imaged with plain radiography or, if severe, with computed tomography.

Appropriate therapy will depend on the type of infection and the results from blood cultures. In summary, a critical approach to fever, suspected infections, and subsequent management with the appropriate antibiotics will help improve outcomes among maintenance HD patients.

Infections have a devastating impact on the health of hemodialysis patients; infections represent the leading cause of visits to emergency departments by hemodialysis patients. Hemodialysis catheters, especially temporary catheters, are more likely to become infected and result in bacteremia than arteriovenous grafts or fistulas. Clinicians must be aware that atypical presentations of infection may occur, particularly in frail older hemodialysis patients. Appropriate cultures should be obtained before starting antibiotics, and clinicians should be familiar with recommended empiric antibiotics for specific types of infections. Finally, the isolation of either *S. aureus*, *Candida* species, or *Pseudomonas* species in blood cultures from patients with suspected hemodialysis catheter infections almost always precludes catheter preservation.

Water Treatment in the Outpatient Hemodialysis Facility

In the infancy of HD, water quality was not a concern. Water was untreated or simply underwent a rudimentary softening process. Now it is appreciated

that the microbial quality of the water used for HD is extremely important because of the potential exposure of patients who have varying levels of immune compromise that accompany uremia and its metabolic consequences.

In the short term, exposure to high levels of bacteria and endotoxin is associated with complications that range from pyrogenic reactions, including chills and fever, to septicemia with severe hypotension and shock (12). Manifestations attributed to endotoxin exposure also include nausea, myalgia, headache, lassitude, and sleepiness.

Long-term exposure to endotoxin challenge may subject susceptible patients to a state of sustained microinflammation that could play a role in the pathogenesis of several chronic complications typical of the uremic state (13), summarized in Table 18.

Within the United States, water for dialysis typically comes from the municipal supply, the quality of which is stringently regulated. Under the Safe Drinking Water Act, the Environmental Protection Agency sets legal limits on contaminant levels in drinking water (14). The limits are based on known toxicity of individual contaminants and on technology available to remove the contaminants. Unfortunately, standards established to ensure safe drinking water do not necessarily ensure safety for use during HD. In a typical 45X formulation-based proportioning system, approximately 94% of the dialysis fluid is purified water, approximately 4% originates from the sodium bicarbonate concentrate, and the remaining 2% is from the acid concentrate.

Dialysis water treatment uses various levels of pretreatment, a final purification module, which is typically reverse osmosis, and a means of distributing the purified water to the point of use (Figure 13). Water of optimal chemical and microbial quality can be produced. However, no single type of purification treatment is capable of delivering chemically and bacteriologically pure water across all facilities because of the geographical variations of municipal water, the maintenance of water systems, and the local level of knowledge, skill, and competency with water treatment application.

The 2008 publication for the End-stage Renal Disease CMS Conditions for Coverage (CfC) references AAMI RD52:12004 *Dialysate for hemodialysis*, AAMI RD62:2001*Water treatment equipment for hemodialysis applications* deemed water standards enforceable as regulation (15,16). As stated in the Association for the Advancement of Medical Instrumentation (AAMI) monograph, "Product water used to prepare dialysate or concentrates from powder at a dialysis facility, or to process dialyzers for reuse, shall contain a total viable microbial count lower than 200 CFU/ml and an endotoxin concentration lower than 2 EU/ml. The action level for the total viable microbial count in the product water shall be 50 CFU/ml and the action level for the endotoxin concentration shall be 1 EU/ml. If those action levels are observed in the product water, corrective measures shall promptly be taken to reduce the levels."

The recommended practice and standards developed by AAMI are as follows: "The standard reflects the conscientious efforts of concerned physicians, clinical engineers, nurses, dialysis technicians, and dialysis patients, in consultation with device manufacturers and government representatives, to develop a standard for performance levels that could be reasonably achieved at the time of publication." AAMI procedures require that action be taken to reaffirm, revise, or withdraw the standards no later than 5 years from the date of publication. Since the publication of the CfC that references RD52:2004 and RD62:2001, both documents have undergone changes as a result of the 5-year process. The latest publication recommends a lower level for bacteria and endotoxin. Facilities may voluntarily adopt the new levels as the unit policy. However, once this occurs, a facility becomes obligated to maintain the levels at the new thresholds, and the new levels become enforceable by CMS.

A comparative chart of the current regulatory levels of RD52:2004 with the updated AAMI

Table 18. Susceptible hemodialysis patients' risk factors

• Malnutrition	• Increased C-reactive protein	• Low cholesterol synthesis
• Low serum albumin concentration	• Resistance to erythropoiesis-stimulating therapy	• Bone disease, cysts, fractures
• Protein catabolism	• Atherosclerosis	• Increased ferritin levels
• Sleep disorders	• Muscle protein wasting	• Antiendotoxin antibodies

Data compiled from reference 13 (Bergström J, Lindholm B, Lacson E Jr, Owen W Jr, Lowrie EG, Glassock RJ, Ikizler TA, Wessels FJ, Moldawer LL, Wanner C, Zimmermann J: What are the causes and consequences of the chronic inflammatory state in chronic dialysis patients? *Semin Dial* 13: 163-75, 2000).

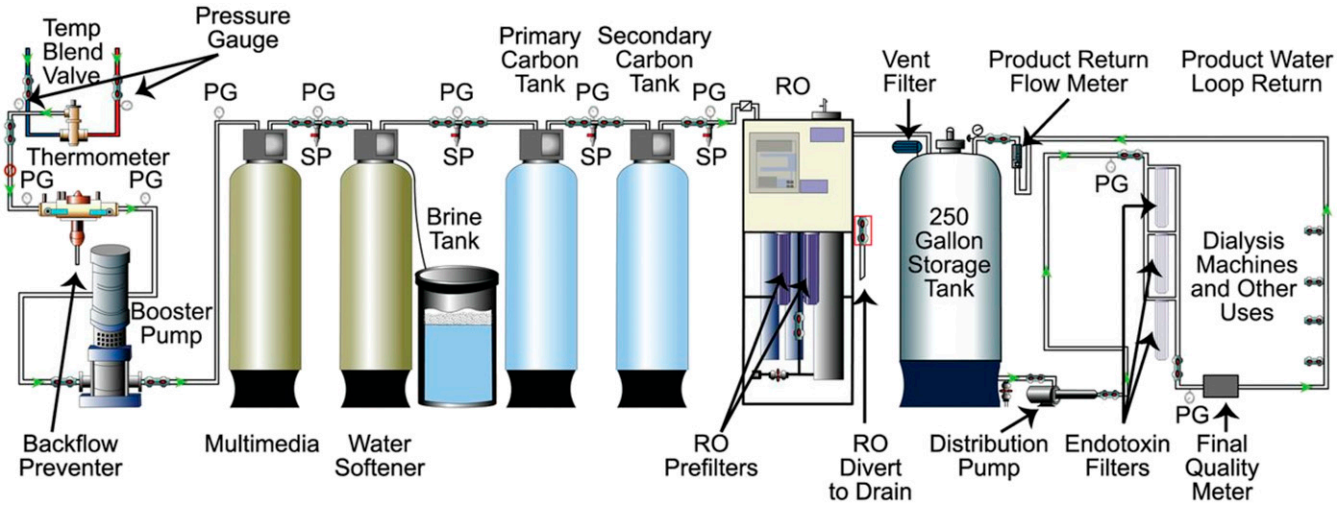

Figure 13. The water treatment system. This schematic illustrates a water treatment system with indirect product water distribution (i.e., a holding tank). PG, pressure gauge; RO, reverse osmosis; SP, sampling port. Reprinted with permission from Kasparek T, Rodriguez OE: What Medical Directors Need to Know about Dialysis Facility Water Management. *Clin J Am Soc Nephrol* 10(6):1061-71, 2015.

standards is shown in Table 19 (28). The allowable culture levels have been reduced from 200 CFU/ml down to 100 CFU/ml for water and dialysate. The significant change is for allowable endotoxin levels. Water allowable is at <0.25 EU/ml and dialysate at <0.5 EU/ml.

Reverse osmosis can achieve water quality that meets the minimum standards established by AAMI. The process of water purification eliminates contaminants, including disinfectant(s) used by municipalities to reduce bacteria in drinking water. Because the purified water no longer contains the municipal disinfectant, the components of the distribution system (storage tank, piping loop, pump heads, filter housing, dialysis machine water line) can be a conducive environment for microbial growth. The technological advancement and sophistication of current systems (*e.g.*, dual-stage and heat disinfection of the reverse osmosis system, ultraviolet irradiation, ultrafilters) allows for the production of water and dialysate at the ultrapure level (17). The responsibility and the challenge faced by the physician and the facility is to maintain the level of quality produced by the appropriately designed water purification system. Maintaining a properly designed system is achievable only with the understanding and knowledge of standards and recommended practice, regulations and water system applications, proper maintenance, and monitoring (18,19).A properly designed water system and program to mitigate patient exposure to bacterial and endotoxin contaminant should include the following:

- A continuous distribution loop with a flow velocity of a minimum of 3 feet/second when using a storage tank, or at 1.5 feet/second when using a direct-feed system. Design of the loop should eliminate any potential dead legs that can result in stagnation.
- When a storage tank is used, the tank should be designed with a conical bottom to allow for complete drainage and a 5-μm vent filter to eliminate aerosolized contaminants from entering the storage tank. The volume of the tank should not be oversized but sized sufficiently to meet the needs of the unit and to allow for several tank volume exchanges during the treatment day.
- Ultrafilters distal to the storage tank.
- Ultraviolet irradiation can facilitate control of the bacterial population.
- A monthly disinfection of the storage tank and distribution system that includes the incoming water line to the dialysis machine.
- Monthly cultures and endotoxin analysis of water and dialysate.
- Water treatment should be part of the Quality Assurance Practice Improvement process.

A key concept in ensuring compliance with the bacteriologic control requirements is that disinfection schedules should be designed to prevent bacterial

proliferation, rather than being designed to eliminate bacteria once they have proliferated to an unacceptable level. Performing cultures and endotoxin measurements represent proactive strategies. The timing of performance of these cultures should be as far away as possible from the last disinfection, *i.e.*, right before the monthly disinfection schedule. Blood for cultures should not be drawn immediately after disinfection. The results of cultures and endotoxin measurements are not a prompt to disinfect the water purification system. The results are "trackable data," indicating that the disinfection schedule and process are successfully controlling bacteria and endotoxin levels below the action level between monthly sampling cycles. Should the results exceed the action level, an adjustment must be made to the disinfection frequency (*e.g.*, twice a month disinfection) or to the disinfection process (*e.g.*, increasing concentration or dwell time).

The minimum sampling source by regulation is as follows:

- From the first outlet of the distribution loop.
- From the last outlet of the distribution loop.
- Where water enters equipment used to reprocess dialyzers.
- Where water enters equipment used to prepare bicarbonate concentrate or from the bicarbonate concentrate mixing tank.
- Additional testing, such as at the end of the water purification cascade and at the outlet of the storage tank, if one is used, may be necessary when troubleshooting the cause of contamination with the distribution loop.
- Dialysate samples from at least two machines monthly and from enough machines so that each machine is tested at least once per year.

The CMS *Interpretive Guidance* requires that "The Medical Director is ultimately responsible for the safety and quality of the water used for patient treatments. The Medical Director must be knowledgeable of the water treatment system installed and assure that the system as installed will produce AAMI quality water" (16). Maximum allowable levels for water quality have been established and recommended by the AAMI. If any values exceed the levels, the Medical Director must be notified and address the high levels. The regulations established for the ESRD community by the CMS do not specify whether to discontinue or continue dialysis in these instances. The Medical Director is ultimately responsible for this decision. The Medical Director must make a medical assessment to determine whether short-term exposure to contaminants may be a more optimal choice than not receiving dialysis.

Keeping water systems and dialysate production safe and infection free is essential for hemodialysis facilities. A key concept in maintaining bacterial control is that the acquisition of cultures and the measurement of endotoxins should be proactive, not reactive, strategies.

Compiling Best Practices to Prevent Bloodstream Infections in the Dialysis Setting

Recognizing the problem and tracking outcomes are key steps in being able to address preventable BSIs in the outpatient HD setting. Another critical step will be providing guidance to Medical Directors, attending nephrologists, and HD patient care staff on best

Table 19. Allowable and action threshold levels of water bacterial cell count and endotoxin tests

Reference	Allowable Water TVC	Action Level Water TVC	Allowable Level Water EU	Action Level Water EU
CfC RD52:2004 (minimum regulatory requirement)	<200	50	2	≥1
ANSI/AAMI/ISO 13959 (preferred recommendation)	<100	50	<0.25	≥0.125
ANSI/AAMI/ISO 23500	<100	50	<0.25	≥0.125
ANSI/AAMI/ISO 11663	<100	50	<0.25	≥0.125
Ultrapure (aspirational)	<0.1		<0.03	
Infusable	10^{-6}		<0.03	

Data compiled from reference 28 (International Organization for Standardization; ISO 23500-1:2019: Preparation and quality management of fluids for haemodialysis and related therapies, 2019. Available at: https://www.iso.org/standard/67610.html).

ANSI, American National Standards Institute; AAMI, Association for the Advancement of Medical Instrumentation; EU, endotoxin unit; ISO, International Organization for Standardization; TVC, total viable count.

practices that may be implemented to achieve the objective of decreasing the risk for and eventually eradicating preventable infections. The CDC, along with its advisory bodies of nephrologists, infectious disease clinicians, and infection preventionists, has reviewed available evidence that support best practices in infection prevention and control in the dialysis setting (20,21). Specifically, the CDC identified nine core interventions that may be used in combination, based on best available evidence, albeit some were obtained from nondialysis settings (22). These core interventions were accompanied by education material and tools that facilitate implementation, some of which have already been implemented in HD centers with encouraging results (23–25). The CDC's nine core interventions are described and summarized below (*https://www.cdc.gov/dialysis/PDFs/Dialysis-Core-Interventions-5_10_13.pdf).*

The first of these core interventions involves monthly tracking and surveillance of BSIs using the NHSN (26). This process involves calculating facility rates and comparison to rates in other NHSN facilities while sharing results with front-line clinical staff. This information closes a feedback loop that allows the front-line staff to gauge how their efforts are translated to clinical outcomes.

The second item deals with emphasizing and performing observations of hand hygiene opportunities monthly. Again, results are shared among the clinical staff. The next two core interventions deal with enhancing stakeholder involvement: ensuring patient care staff education and competency and enhancing patient education and engagement. These four basic activities provide a fundamental foundation to establishing an outpatient HD infection prevention program (23).

As established by epidemiologic and clinical data above, vascular access infections are the major component of preventable HD infections. Incorporating efforts (*e.g.*, through patient education, vascular access coordinator) to reduce catheters by identifying and addressing barriers to permanent vascular access placement and catheter removal is a key core intervention. However, it is no surprise that a series of four recommended core interventions specifically address vascular access care, with a strong focus on HD catheter care.

The first core intervention in this series of four is conducting quarterly observations of vascular access care and HD catheter manipulations to assess staff adherence to aseptic technique when connecting and disconnecting catheters and during dressing changes. Sharing results with clinical staff reinforces focus on this important step. The second intervention is to use an alcohol-based chlorhexidine (>0.5%) solution as the first-line skin antiseptic agent for central line insertion and during dressing changes. If a patient is intolerant to chlorhexidine, povidone-iodine (preferably with alcohol) or 70% alcohol can be used as alternative. The third intervention is scrubbing catheter hubs with an appropriate antiseptic after the cap is removed and before accessing. This intervention is performed every time the HD catheter is accessed or disconnected. However, if a closed needleless connector device is in use, the device is best disinfected per manufacturer instructions (22). The fourth HD catheter core intervention is controversial and involves application of antibiotic ointment or povidone-iodine ointment to catheter exit sites during dressing change. Bacitracin/gramicidin/polymyxin B ointment is not currently available in the United States. Triple antibiotic ointment (bacitracin/neomycin/polymyxin B) is available and might have a similar benefit, but studies have not thoroughly evaluated its effect for prevention of bloodstream and exit-site infections.

Other ointments that have been studied include single antibiotic ointments (*e.g.*, mupirocin). However, concerns exist about development of antimicrobial resistance and the ability of these ointments to cover the spectrum of potential pathogens (*e.g.*, gram-negative and gram-positive bacteria) that can cause BSIs in dialysis patients. Another important consideration is that ingredients in antibiotic and povidone-iodine ointments may interact with the chemical composition of certain catheters. Therefore, before any product is applied to the HD catheter, checking compatibility of the selected ointment with the catheter manufacturer first helps to avoid interactions with the catheter material (22).

More specific information about these core interventions is discussed throughout the other sections of this syllabus. Medical Directors should be able to use the information in this syllabus to conceptualize leadership of an infection prevention and control program, and attending nephrologists as situational leaders should be able to grasp why they are important partners in its success. Once physicians are united, it will be less difficult to motivate and train staff on infection control topics, including access care and

aseptic technique. Physicians and designated nurse mangers and staff should be able to perform competency evaluation for skills such as catheter care and accessing every 6 to 12 months and when new staff are hired (22). Most important, all clinic staff and clinicians need to capably provide standardized education to all patients on infection prevention topics, including vascular access care, hand hygiene, risks related to catheter use, recognition of signs of infection, and instructions for access management when away from the dialysis unit. Patients also need to be engaged as partners in their healthcare for infection prevention to be effective (27).

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Other Infection-Related Issues, Disaster Preparedness, and Resources for Outpatient Hemodialysis Facilities

State Healthcare-Associated Infection Programs

Most nephrologists are familiar with the role of the CDC, but there are also opportunities for state-level healthcare-associated infection (HAI) organizations to play a crucial role in infection control and elimination

in dialysis patients. The 50 United States and Puerto Rico have state-level initiatives that tackle various HAI monitoring arrangements for multidrug-resistant organisms (1). The structure and scope of the state HAI programs vary based on the policies and laws established in each state. Ideally, from a CDC perspective, state HAI programs should have a clearly defined site for public data reporting of HAIs with subsequent data validation. Also, healthcare providers should have the ability to respond to HAI threats, especially emerging HAIs, in an efficient and timely manner. The state HAI programs could work in conjunction with the CDC to support infection surveillance in HD units. Even though most states with public reporting legislation choose the NHSN for data collection, some have implemented state-specific HAI reporting systems. Some HAI programs have access to NHSN data to help implement surveillance and prevention programs. State HAI programs usually have at least one coordinator that is funded by the CDC as part of the Affordable Care Act (2,3).

Nephrologists, particularly Medical Directors of dialysis units, must be aware of their state-level HAI programs and any applicable reporting requirements. In addition to state HAI programs, physicians should also be cognizant of infection-reporting requirements at the city level. One of the goals of the ASN Nephrologists Transforming Dialysis Safety (NTDS) initiative is to have an easily accessible website that will guide physicians to the reporting requirements at the level of each state. The Council of State and Territorial Epidemiologists also works closely with state and federal health agencies to facilitate collaboration and may be a knowledgeable resource for nephrologists and Medical Directors because they support training and peer consultations. Each state has a point of contact for infectious diseases that may be available to assist the dialysis facility staff, nephrologists, and Medical Directors in infection prevention and control (4).

Preparedness for Emerging Threats

Emerging infectious diseases present special challenges for dialytic therapies because of their severity and ease of transmission. Additional personal protective equipment (PPE) and more extensive procedures for donning, doffing, and discarding PPE are required. Patients with Ebola virus disease have required dialytic therapies because of severe volume and electrolyte derangements. The CDC has published recommendations for safe, acute HD in patients with Ebola virus disease (5). Strict adherence to biocontainment procedures, impermeable PPE, dedicated equipment, and strategies to minimize healthcare worker exposure are required. Continuous modalities are preferred to decrease transmission resulting from fewer filter exchanges, less frequent manipulation of vascular accesses, a decreased rate of dialysate production, and the lower number of nursing personnel required to operate continuous renal replacement therapies (5–7). Although high-flux, high-efficiency dialyzers may be impermeable to the Ebola virion, the effluent from EVD patients receiving dialysis should be treated as infectious waste (6,7). One proposed therapy is lectin-affinity plasmapheresis, whereby a sorbent-containing filter in series with the dialyzer adsorbs viral particles and reduces viral load during renal replacement therapy (8). Anecdotally, the Liberian patient treated in Dallas reportedly received continuous renal replacement therapy as part of his care. It remains unclear how two nurses who cared for this patient became infected, and it is possible that exposure to blood related to the continuous renal replacement therapy procedure may have had a role in transmission (9).

Infection with the Middle Eastern respiratory syndrome coronavirus (MERS-CoV) is a highly contagious illness. There is no direct relationship between MERS-CoV and AKI. However, HD patients are at higher risk of infection because of the increased time spent in hospital-based facilities. Most of the reported patients with MERS-CoV infections were exposed during face-to-face contact in HD facilities or intensive care units (10,11). Guidelines for HD facilities during MERS-CoV outbreaks have been published and include recommendations to prohibit interhospital transfers (12). Similarly, lectin affinity plasmapheresis is undergoing evaluation for potential future use (13).

A summary for these two outbreaks is shown in Table 20. During outbreaks, state public health authorities will provide criteria that dialysis providers can use to screen and identify cases. Public health authorities may provide facilities with appropriate biocontainment areas for provision of dialysis or transport of dialysis patients from home to facility during epidemics.

Overall, preparedness for emerging threats requires that nephrologists pursue educational opportunities and emphasize the importance of vigilance and close contact with public health and health departments for update(s) and guidance. Medical Directors must

Table 20. Emerging infectious agent epidemics in the hemodialysis setting

Emerging Infectious Agent	PPE	Modality	Effluent	Machine Disinfection
Ebola	Single-use impermeable gown/coverall, PAPR or N95 respirator, double-gloves, single-use boot-covers, single-use apron, separate donning and doffing areas	CRRT	Treat as infectious waste	Use U.S. Environmental Protection Agency—registered disinfectant recommended for use against Ebola, vaporized hydrogen peroxide, ultraviolet light decontamination for external surfaces; standard manufacturer's guidelines for internal pathways performed in isolation room
MERS-CoV	Gloves, eye protection, gown, highly efficient mask	No specific recommendation	No modification to standard practice	No modification to standard practice
Swine/avian flu	Gloves, eye protection, N95 respirator, gowns	No specific recommendation		
What's next?				

Original table courtesy of Dr. Gregory H. Gorman, CAPT, MC, USN, Walter Reed Bethesda Children's Center (Bethesda, MD).

CRRT, continuous renal replacement therapy; MERS, methicillin-resistant *Staphylococcus aureus*; PAPR, Powered Air-Purifying Respirator.

deliberate about how to best prepare their facilities for the next emerging threat by having a plan in place for spatial separation of patients, communication plans with public health and other local healthcare facilities, emergency staffing, and coordination with local infectious disease experts. These plans may be promulgated with specific dialysis facility activities for compliance with initiatives for disaster preparedness consistent with the September 8, 2016, CMS final rule, "Emergency Preparedness Requirements for Medicare and Medicaid Participating Providers and Suppliers" (14).

Herpes Zoster in Hemodialysis Patients

Commonly called shingles, herpes zoster (HZ) is a DNA viral infection caused by the varicella-zoster virus (VZV). HZ is particularly common among adults more than 50 years old. HZ represents the local skin manifestations attributed to viral reactivation. VZV is highly transmissible via infected fluid in vesicles. Patients with ESRD are at increased risk for the development of HZ infection (15). Individuals who do not receive zoster vaccine and live to 85 years of age have a 50% risk of HZ, according to one estimate (17). Although fewer maintenance dialysis patients live to this age, they may be similarly at risk.

In all cases of HZ, standard infection control precautions should be followed, and lesions completely covered. If the patient is immunocompromised or if disseminated zoster, defined as "appearance of lesions in >3 dermatomes," is suspected, Then airborne and contact precautions, in addition to Standard Precautions, must be adhered to until lesions are dry and crusted (16). If airborne and contact precautions are indicated, then the patient cannot receive HD in an outpatient facility and needs to be transferred to a facility that can handle airborne and contact precautions. Achieving the latter may require hospitalization.

The treating nephrologist should be promptly contacted for initiation of antiviral therapy and any other recommendations. Antiviral agents have been shown to reduce the duration of HZ lesions, decrease viral shedding, and lower the intensity of acute pain without reducing the risk of postherpetic neuralgia (17). Patients suspected of having HZ and who experience new-onset visual symptoms must be evaluated by an ophthalmologist.

The CDC recommends vaccination against HZ in immunocompetent adults 50 years or older, absent an acute case of HZ (18). Specifically, the preferred lyophilized VZV glycoprotein E antigen and

accompanying AS01B adjuvant suspension (Shingrix, GlaxoSmithKline; available at https://www.shingrix.com/index.html), herein referred to as recombinant zoster vaccine (RZV), approved by the FDA in 2017 is administered in two doses, separated by 2 to 6 months. Alternatively, a single dose of the older, live-attenuated virus vaccine, zoster vaccine live (ZVL), approved by the FDA in 2006 (Zostavax, Merck; available at https://www.zostavax.com) may be used in immunocompetent patients 60 years or older. Patients who are dialysis dependent may be vaccinated for HZ except for those who are severely immunocompromised, including those receiving immunosuppressive agents such as steroids for prior kidney transplantation.

Two doses of RZV (Shingrix) are more than 90% effective at preventing shingles and postherpetic neuralgia. Protection is maintained above 85% for at least 4 years in an immunocompetent (nondialysis) population aged 50 years and older (18). There are currently no published studies on the use of RZV (Shingrix) in patients receiving maintenance dialysis. A single dose of ZVL (Zostavax) is claimed to lower the risk of HZ by approximately 50% and postherpetic neuralgia by 67% (19). Effectiveness is documented for a median of 3 years in the immunocompetent host. Differences in efficacy between RZV (Shingrix) and ZVL (Zostavax) are most pronounced among older patients. Studies have shown that the effectiveness of ZVL (Zostavax), a live attenuated virus, wanes substantially over time, leaving recipients with reduced protection against HZ (20). For example, the CDC notes that the vaccine efficacy among adults 70 to 79 years old and adults 80 years old and older is 41% and 18%, respectively, on average during the first 3 years after ZVL (Zostavax) vaccination. The CDC states that there are no data to indicate that RZV (Shingrix) would be less safe or effective if administered less than 5 years after a patient receives ZVL (Zostavax). ZVL (Zostavax) can be administered to ZVL (Zostavax)-immunized individuals after an interval of no less than 8 weeks (20). From their package inserts updated April, 2019, and May, 2019, respectively, both ZVL (Zostavax) and RZV (Shingrix) may cause local pain (54% versus 88%), erythema (48% versus 39%), and swelling (40% versus 30%). In severely immunosuppressed individuals, the live virus vaccine may result in disseminated VZ disease and even death (18).

Tseng and colleagues (21) from Kaiser Permanente, Southern California, recently examined the effectiveness of ZVL (Zostavax) among 582 maintenance HD patients (matched 1:5 to nonvaccinated ESRD control individuals) who were at least 60 years of age. The investigators concluded that this vaccine lowered the incidence of HZ infection by 50% compared to those who did not receive the vaccine over a 5-year study period. The effectiveness of this vaccine was superior if administered early after initiation of dialysis, particularly within the first 2 years. A preliminary study in 26 pretransplantation dialysis patients at least 50 years of age on the kidney transplantation wait list indicated a response after approximately 5 weeks, with no impact on panel-reactive antibody titers (22). The prevalence of "shingles" and postherpetic neuralgia in patients receiving HD was reported at 22.3/1000 patient-years versus 11.7/1000 patient-years in the vaccinated group of the Kaiser study (21). Although this was a single study and the results have not been replicated in other dialysis settings, vaccination should be considered for all eligible patients barring contraindications or concerns such as low likelihood of short-term survival in an individual patient. Further studies are warranted to evaluate the effectiveness of RZV (Shingrix) and its duration of protection against VZV infection among dialysis patients.

Bed Bugs in Hemodialysis Patients

Bed bugs are small brown insects that feed on human and animal blood. Adult bed bugs are about 5 mm in length with reddish-brown, oval, flat bodies. They are active at night and during the day, and they hide in tiny crevices in mattresses, box springs, bed frames, furniture, floors, or walls. They can be seen and are sometimes mistaken for ticks (23). Although a nuisance, bed bugs are not known to spread disease (24,25). Many people experience an itchy skin welt a day after the bite. The medical concern is usually limited to itching and inflammation of the welts. Infestations may cause anxiety and loss of sleep. Outpatient dialysis settings are not hospitable environments for bed bugs. So, risk for facility infestation is low (24).

Bed bugs are usually unknowingly transported into homes. People carry them on luggage, clothing, beds, and furniture, especially used beds and sofas. Once inside the home, they spread from room to room.

Table 21. Compilation of potential ways to address bed bug infestation in hemodialysis units

Cover dialysis chair with white paper to easily identify bed bugs.
Use active bed bug monitors to determine whether bed bug infestation is present in facility. Traps such as those that emit carbon dioxide may be used to monitor bed bug populations. Captured bugs can be evaluated.
Educate patient and staff. Provide instructions to patient for treatment of home and belongings that have had bed bugs.
Limit personal belongings being brought into clinic (*e.g.*, blankets, bags, purses, clothing) including wheelchairs from infested home. Use large containers with smooth inner surfaces and lockable lids to hold patient belongings and patient clothing during dialysis, if needed. Bedbugs cannot climb smooth surfaces easily.
Bag all of the patient's belongings and have the patient undergo dialysis in a disposable gown; or, as a less embarrassing alternative, give the patient directions to wash/dry the clothing worn to dialysis on the "hot" setting; put clean clothes in a sealed container or garbage bag; patient must take a shower and wash hair/mustache/beard before putting on the clean clothes and presenting for treatment (ensure that patient's shoes, coat, and other garments are free of bed bugs).
Use dialysis chairs at ends of floor to best isolate bed bugs. Keep everything off floors in the vicinity of chairs to isolate bed bugs. Restrict chairs for only bed bug–infested patients, if possible.
Consider investing in a heating box to treat the patient's belongings. Dialysis facilities have used portable heating units with success. All stages of bed bugs are susceptible to temperatures above 120°F.
Assist the patient in identifying sources of assistance for home fumigation. Provide community resources to assist patient with home treatment.
Waiting rooms, visitor lounges, common areas, laundry rooms, and equipment such as wheelchairs and food carts should be regularly inspected for bed bugs.
Isopropyl alcohol is quite effective at killing bed bugs; 91% alcohol is recommended. Facilities should review Material Safety Data Sheets of proposed insecticides/pesticides for safe applications in healthcare occupancy and on items in affected areas (*i.e.*, flame retardant properties of dialysis chairs, molecular size and absorption rate)
Alpine Dust insecticide
Diatomaceous earth
SteriFab
Although bed bugs do not jump, they are excellent hitchhikers. Staff who handle patients may have bed bugs transferred to their clothing. Therefore, staff should practice changing into clean scrubs and putting the old scrubs into a hot dryer for 30 minutes. Shoes can also be put into the hot dryer.

Data summarized from reference 40 (Chronic Kidney Disease Presentation and Discussion, by The Renal Network, Inc for ESRD Networks 4, 9, and 10 on Tuesday, April 23, 2013. Available at http://www.therenalnetwork.org/services/resources/BedBugs/Bedbugs_Blueberries.pdf).

They can survive for months without food or water (23). Inside buildings, bed bugs breed all year, and typically breed up to three generations per year. Their lifespan is 10 months to just over 1 year, during which time females may lay from 200 to 400 eggs, depending on temperature and food availability (http://cisr.ucr.edu/bed_bugs.html). Females need a blood meal before laying eggs. Bed bugs feed for approximately 5 to 10 minutes at night. In addition to a blood source, bed bugs must molt to progress into the next stage of growth. The molted skin often signifies infestation (26).

A compilation of various steps that have been recommended by experts and dialysis personnel who have experience with bed bug infestation (24) is summarized in Table 21 (40). Additional resources on bed bugs can be found at the CDC website (available at https://www.cdc.gov/nceh/ehs/topics/bedbugs.htm (39).

Although a nuisance, bed bugs do not spread disease. They may produce itching, inflammation of welts, and loss of sleep because of associated anxiety. There are various ways to treat bed bugs, and dialysis facilities must investigate which treatment is best for their circumstances.

Head Lice in Hemodialysis Patients

A head louse (Pediculus humanus capitis) is a tan or grayish insect about 2 to 3 mm in length. It feeds on human blood that it extracts from the scalp. Itching on the scalp, neck, and ears is the most common symptom. This is an allergic reaction to the insect's saliva. After the initial infestation, an individual may not experience itching for 2 to 6 weeks (28). Scratching an itchy scalp from head lice may produce skin breaks,

leaving the scalp vulnerable to infection; head lice do not carry bacterial or viral infectious diseases (28,29).

Most often, transmission of head lice from one person to another is by direct contact. Indirect transmission is unlikely, but lice may spread from person to person by items such as hats, scarves, brushes, combs, hair accessories, headphones, pillows, upholstery, and towels (28). Indirect transfer could also occur among items of clothing stored together. However, lice usually don't live past 1 day without feeding from a scalp, and eggs do not survive if they are not incubated at near-scalp temperatures. Therefore, the chance of lice surviving away from the host on household items or equipment is small.

The female louse produces a sticky substance that adheres each egg to a hair shaft. An egg is attached approximately 4 mm from the base of the shaft, an environment that provides an ideal temperature for egg incubation. Louse eggs hatch after 8 or 9 days, and nymphs emerge. Nymphs become mature adult lice after 9 to 12 days and survive for 3 to 4 weeks (27, 28).

The crterion standard for diagnosing an active infestation is identification of a live nymph or adult louse. The guidelines from the American Academy of Pediatrics recommend an examination of wet hair, lubricated with such products as a standard hair conditioner. The hair should be combed with a fine-toothed comb (nit comb) from the scalp to the end of the hair. If a live louse is not found, this process should be repeated at a second appointment (29).

An examination for nits should also be done. A specialized ultraviolet light called a Wood's lamp, which causes nits to appear bluish, is used for this examination, but the identification of nits does not necessarily confirm the diagnosis of an active infestation. A live nit needs to be near the scalp to incubate. Nits found more than about 6 mm from the scalp are likely dead or empty. Suspected nits can be examined under a microscope to determine viability—evidence of a likely active infestation. If no live nits are found, active infestation is unlikely.

Because lice are not associated with serious medical problems, the primary consideration of the American Academy of Pediatrics regarding treatment is the safety of pediculicides and other products used to treat head lice (30). Current treatment options have included over-the-counter (OTC) and prescription medications (28,31) OTC medications are based on pyrethrin, a chemical compound extracted from the chrysanthemum flower that is toxic to lice. Rinsing the hair with white vinegar before washing may help dissolve the glue that holds the nits to the hair shafts. Do not use a combination shampoo/conditioner or conditioner before using lice medicine. Also, do not rewash the hair for 1 to 2 days after the lice medicine is removed.

OTC medications include the following:

- Permethrin (Nix). Permethrin is a synthetic version of pyrethrin. Side effects may include redness and itching of the scalp.
- Pyrethrin with additives (Rid, A200 Lice Treatment). In this OTC medication, pyrethrin is combined with another chemical that enhances its toxicity. Side effects may include itching and redness of the scalp. Pyrethrin should not be used for patients allergic to chrysanthemum or ragweed, a common allergy.

In some geographic regions, lice have developed resistance to OTC medications. Also, OTC treatment may fail because of incorrect use, such as not repeating the treatment at an appropriate time. Therefore, prescription medications are required for therapy:

- Benzyl alcohol topical 5% lotion (28–30). This product is nontoxic to lice but kills them by depriving them of oxygen. Side effects may include redness and itching of the scalp. The use of benzyl alcohol to disinfect medical devices may induce seizures and other severe reactions in newborn infants. Therefore, lice treatment with benzyl alcohol is not approved for use in children less than 6 months of age.
- Ivermectin lotion 0.5% was approved by the FDA in 2012 for treatment of head lice in persons 6 months of age and older. It is not ovicidal but appears to prevent nymphs (newly hatched lice) from surviving. It is effective in most patients administered as a single application on dry hair without nit combing. It should not be used for retreatment without discussion with a healthcare provider. Given as a tablet in mass drug administrations, oral ivermectin has been used extensively and safely for over two decades in many countries to treat filarial worm infections. Although not FDA approved for the treatment of lice, ivermectin tablets administered as a single oral dose of 200 μm/kg or 400 μg/kg repeated in 9 to 10 days has been shown effective

against head lice. It should not be used in children weighing less than 15 kg or in pregnant women.

- Malathion lotion 0.5%. Malathion is FDA approved for use with persons 6 years old or older. Malathion is pediculicidal (kills live lice) and partially ovicidal (kills some lice eggs). A second treatment is recommended if live lice still are present 7 to 9 days after treatment. Malathion can be irritating to the skin. The medicated shampoo is applied, left to dry naturally, and rinsed out after 8 to 12 hours. The drug has a high alcohol content, so it should not be used with a hair dryer or near an open flame.
- Spinosad topical suspension 0.9%. This product is derived from soil bacteria. Spinosad was FDA approved in 2011. Because it kills live lice as well as unhatched eggs, retreatment is usually not needed. Nit combing is not required. Spinosad topical suspension is approved for the treatment of children 6 months of age and older. It is safe and effective when used as directed. Repeated treatment should be given only if live (crawling) lice are seen 7 days after the initial treatment.
- Lindane shampoo 1% is recommended as a second-line therapy by the CDC (32). It is used only after first-line treatments have failed, are contraindicated, or are not available. This medicated shampoo has a risk of severe side effects, including seizures, and is used only when other treatments have failed. It is not recommended by the American Academy of Pediatrics for use in children. The FDA warns that it should not be used on anyone who weighs less than 110 pounds (50 kilograms), is pregnant or breast-feeding, has a history of seizures, or has HIV infection.

A recent review of the literature summarized the evidence and noted a marked decline in effectiveness of permethrin and synergized pyrethrins, likely attributable to widespread indiscriminate use and emergence of resistance mutations (32). The authors further noted potential toxicity of lindane in the setting of readily available, safer, and more effective alternatives that should limit its use. Prescription products shown to be safe and effective with a single application, without nit combing, are topical ivermectin, malathion, and spinosad, whereas benzyl alcohol requires two applications (28,29). Of note, home remedies such as mayonnaise and essential oils, have not been demonstrated to be safe or effective, and they may carry potential for severe adverse events. The high risk of failure of OTC treatments in eliminating head louse infestations drives a need for healthcare provider to recognze the limitations of current treatments and for judicious use of treatments that remain effective.

As a precaution, the patient/family may be instructed to clean items that the affected person has used in the previous 2 days. Cleaning recommendations include the following (28,31):

- Wash items in hot water. Wash bedding, stuffed animals, and clothing in hot, soapy water—at least 130°F (54.4°C)—and dry at high heat.
- Clean hair care items. Clean combs, brushes, and hair accessories in hot soapy water.
- Seal items in plastic bags. Seal items that cannot be washed in plastic bags for 2 weeks.
- Vacuum floors and upholstered furniture.

Do not use fumigant sprays or fogs; they are not necessary to control head lice and can be toxic if inhaled or absorbed through the skin.

Patient Education and Engagement

For optimal success in any diagnostic and therapeutic recommendation(s) and/or intervention(s), communication with and engagement of the patient and his/her personal support system is essential. However, for patients receiving maintenance dialysis, infectious complications may not be their prime concern. In a recent study performed in Canada to assess dialysis patients' views and satisfaction with their vascular access, Kosa and colleagues (33) reported that infectious complications, including catheter-related infections, were viewed as less important than physical complications from cannulation. Similar findings were later reported in a Delphi-type survey and analysis that indicated patient preferences for lifestyle-related outcomes over clinical outcomes that healthcare professionals valued, such as infection prevention and control (34). However, such patient preferences may have been due, at least in part, to inadequate knowledge regarding the importance of infection control and its subsequent impact on lifestyle. The essential components of patient education should include but are not limited to the following issues: proper hand hygiene techniques for patients and caregivers, optimal vascular access options, appropriate catheter care procedures, and prompt identification of early signs of infection (35). It is important to appreciate that education of dialysis patients is not

a one-time undertaking but is rather an ongoing effort by multiple members of the dialysis team (36). This process should start early in the process of dialysis.

Once engaged, dialysis patients consider their perspectives vital and highly value their involvement in infection control efforts at dialysis facilities (37). In a study conducted by Miller and colleagues (38), dialysis patients and caregivers underscored the importance of patient education and engagement in the development of clinical practice guidelines to address infection control at dialysis facilities. Specifically, patients requested comprehensive education regarding infectious microorganisms and their transmission in dialysis facilities to understand the risks to themselves and others and contain the spread of infections. In addition, owing to their concerns over disclosure of information on unsafe practices by the dialysis team negatively impacting their care, patients requested an anonymous service through which they could voice their concerns (38). Patient education and engagement regarding infection control may be best achieved with a tailored approach based on the unique attributes of individual dialysis facilities and commitment from the dialysis team.

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Natural Disasters and Disaster Preparedness

Goals

The treatment of persons receiving renal replacement therapy before, during, and after a disaster can be complicated and stressful. Resource supply and availability and environmental conditions are unlikely to be similar to those in the predisaster time period.

The goals to effectively manage a dialysis facility and care for patients during a disaster are to:

- Ensure safety of employees, patients, and visitors
- Provide availability of dialysis care
- Protect electronic and hard copy clinical and business records
- Mitigate damage to property and contents
- Return to normal operations as soon as possible

A major disaster will increase the burden on public safety and medical resources exponentially. Therefore, a dialysis facility should prepare to be self-sufficient for several days after the disaster.

Preparedness

To plan for the safety of patients, employees, and visitors, it is imperative that facilities conduct routine emergency preparedness drills and review emergency procedures. This review should include the possible requirements for modifications of the infection prevention/control processes, with an eye toward mitigation of problems or lack of resources. Important items to consider include the availability of clean water (drinking, hand hygiene), additional PPE supplies (potential for additional isolation requirements), and additional water testing supplies (more frequent testing).

When a disaster is expected, staff should prepare patients for the possibility that dialysis treatment may be delayed or rescheduled or conducted at a different facility. Emergency plans should be reviewed with patients, especially aspects of infection control/prevention such as access care, hand hygiene, monitoring water advisories from local community news systems, and signs/symptoms of infection. Patients must know whom to call with any dialysis-related or infection-related issues.

Before disasters occur, the facility staff must review disaster procedure instructions with patients. Patients must receive specific instructions on steps to take before, during, and after disaster strikes. Instructions regarding how to determine whether a facility is open and whom to ask about problems is necessary. Dialysis facilities that are not open for business must track their patients to determine whether treatments are carried out.

Resources

Water

Water is the most frequently impacted resource during disasters. Water supplies may be contaminated or disrupted. Adequate amounts of water to perform dialysis will need to be delivered to the dialysis site in an approved tanker if the local water source is unavailable. Tankers used for milk and water are preferred, but trucks employed for the transport of

wine, beer, and vegetable oil may be used. Tankers, hoses, and pumps should be cleaned and sanitized before transport, and water should be chlorinated to 1 part per million (ppm) and no more than 4 ppm. Water may be used from wells after meeting microbiological, chemical, and radiological standards. The depth of a well generally correlates with the risk of microbiological contamination but is insufficient to certify the water supply as safe. Once local water is available, the water filtration system may require augmentation because of hyperchlorination, excess particulate matter, and microbiological contamination. It is essential that the dialysis facility staff remain informed about the status of local water availability. Before returning to local water usage, staff must follow specific protocols and procedures to disinfect and test the dialysis facility's water and dialysate delivery systems.

Hand Hygiene

The use of appropriate hand hygiene is imperative during a disaster. The type and frequency of hand hygiene will depend on the available resources (*e.g.*, if water is not available or limited, reliance on alcohol-based hand sanitizer may increase). Hand hygiene remains the first defense against infection in any situation.

Peritoneal Dialysis

Modifications may be necessary for patients treated by peritoneal dialysis during a disaster situation. Special care must be taken by patients using peritoneal dialysis to prevent infection, especially after natural disasters when flooding is present, access to medical supplies is limited, or peritoneal dialysis patients must board in temporary housing/emergency shelters. The CDC provides guidance for the care of individuals using peritoneal dialysis during a disaster (1).

Infection-Related Processes and Protocols

Disease transmission increases during a disaster. Dialysis facilities should have infection prevention protocols for identifying all infections, including healthcare-associated infections and potentially contagious patients, visitors, and staff. Activated protocols depend on the nature of the disaster (natural versus man-made, bioterrorism, infectious disease outbreak, or pandemic). Triage and surveillance are key to infection prevention and disease transmission. The staff must use Standard Precautions and PPEs and implement transmission-based precautions or isolation, if necessary.

If the dialysis facility sustained damage or needed to be closed as a result of a disaster, multiple steps are necessary to ensure that the facility is safe for the return of patients and staff. First and foremost, it is important to know that the facility has been inspected and is structurally sound. Next, damage assessment must be done, and a plan to move forward with repairs as necessary follows. The water system must be examined, tested, sterilized, and retested. Guidance for water system startup after a disaster can be found on the CDC website (2).

Waste

Contaminated waste management is a critical feature of disaster management. Improper waste disposal promotes infection and endangers the public health. Before disasters take place, the dialysis facility must review its current processes, contact the waste disposal vendor, and develop a plan to dispose of or store contaminated waste materials until routine disposal is available. Environmental cleaning and disinfection policies and procedures should also be evaluated before disasters, and staff should review processes that may require modification after a disaster (*e.g.*, returning to a facility that has been closed for a period of time or has been contaminated by dirt, debris, or water).

Centers for Medicare & Medicaid Services Guidance

The Centers for Medicare & Medicaid Services resource, "Emergency Preparedness for Dialysis Facilities: A Guide for Chronic Dialysis Facilities" details preparation before a disaster, mitigation, response, and recovery after disasters (3). The CMS, in collaboration with the renal community and the Kidney Community Emergency Response (KCER) coalition, has also developed guidance for patients undergoing dialysis treatments, "Preparing for Emergencies: A Guide for People on Dialysis." Additionally, the Home Dialysis Central webpage provides advice for patients who use dialysis at home (4).

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Acknowledgement

Dr. Lacson and the leadership of NTDS are honored to present this manuscript for all members of the nephrology care team, including physicians, nurses, and technicians. A work of this scope calls for expertise from all of the disciplines on the care team. For their contributions, Dr. Lacson would like to acknowledge the CDC staff and NTDS Project Committee members and additional contributors who provided their knowledge and time in the creation of this Special Edition.

Kenneth Abreo, MD, Sharon Adler, MD, FASN, Ibironke Apata, MD, Stephanie Booth, BSHCA, John M. Boyce, MD, Gregory Braden, MD, Danilo Concepcion, CBNT, CCHT-A, FNKF, Bonnie Freshly, MEd, CMP, Gregory Gorman, MD, MHS, Nicole Gualandi, RN, MS/MPH, CIC, Sally Hess, MPH, CIC, Jerry W. Jackson, MD, FACP, Edward R. Jones, MD, Adrian Mackey, MPH, Paul Martin, MD, Duc Nguyen, MD, Dean Norman, MD, Priti Patel, MD, MPH, Marie Philipneri, MD, PHD, Darlene Rodgers, BSN, RN, CNN, CPHQ, Susan Stark, Anitha Vijayan, MD, FASN, Sana Waheed, MD, Bradley Warady, MD, Leslie Wong, MD, MBA, FASN, Thomas Yoshikawa, MD.

Infection Control and Prevention in Outpatient Hemodialysis Facilities

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MOC points will be applied to only those ABIM candidates who have enrolled in the MOC program. It is your responsibility to complete the ABIM MOC enrollment process.

NephSAP Volume 18, Number 3, July 2019—Infection Control and Prevention in Outpatient Hemodialysis Facilities Examination

1. As the medical director of a dialysis unit you are reviewing the medical records of a 56-year-old patient with diabetes mellitus, hypertension, and a history of intravenous drug abuse who is going to start in-center hemodialysis at your dialysis center. Laboratory studies reveal negative hepatitis B surface antigen, a negative hepatitis B e antigen, a positive hepatitis B surface antibody, a positive hepatitis B core antibody, and a negative Ig M hepatitis B core antibody.

Which ONE of the following statements is TRUE regarding his need for isolation and hepatitis B status?

A. The patient does not need to be isolated because he likely has chronic hepatitis B infection
B. The patient does not need to be isolated because he has developed immunity as a result of immunization
C. The patient does not need to be isolated because the anti-hepatitis B core antibody is likely a false positive result
D. The patient does not need to be isolated because he has developed immunity as the result of a prior hepatitis B infection
E. The patient does not need to be isolated because he is recovering from an acute hepatitis B infection

2. A 55-year-old man who has been receiving maintenance hemodialysis for 5 years is undergoing evaluation for kidney transplantation. Serum liver chemistries are normal. Serologic studies show a positive hepatitis C antibody, a positive hepatitis B surface antibody, a positive hepatitis B total core antibody, a negative hepatitis B surface antigen, and a negative hepatitis B e antigen. The hepatitis C RNA level by polymerase chain reaction is 26,000,000 U/ml.

Which ONE of the following interpretations is CORRECT?

A. He has both active hepatitis B and hepatitis C infection
B. He has hepatitis C infection and has been vaccinated against hepatitis B
C. He has hepatitis C infection and has previously been infected with hepatitis B
D. He has immunity to both hepatitis B and hepatitis C because of prior infection

3. A 70-year old man with advanced chronic kidney disease due to IgA nephropathy is evaluated 1 week before the planned initiation of hemodialysis. He was born in South Korea and moved to the United States 25 years ago. A 5-tuberculin-units purified protein derivative (PPD) tuberculin skin test shows 15 mm of induration. He does not recall receiving Bacillus Calmette-Guérin (BCG) vaccination.

Which ONE of the following is the next BEST step in this patient's management?

A. Perform a 10-tuberculin-units PPD tuberculin skin test
B. Order an interferon-γ release assay
C. Order a chest radiograph
D. Inform the patient that this test result is likely a false positive because of prior BCG vaccination
E. Initiate isoniazid prophylaxis at 300 mg daily

4. A 68-year-old man visiting from an outside dialysis center is evaluated during routine dialysis rounds. He has been receiving hemodialysis for the past 3 months after a kidney transplantation failed because of chronic rejection. His immunosuppression has been tapered to prednisone 5 mg daily. He has had low-grade fever, malaise, and a pruritic rash that is intermittently painful over the chest, abdomen, and thighs for 1 week. On physical examination, his temperature is 37.9° C. Other vital signs are normal. Many clusters of dry and crusted skin lesions are noted on the left side of the chest. Numerous vesicles, pustules, and scabs in various stages of eruption are seen over his lower abdominal wall and proximal thighs. The face, neck, upper extremities, and skin

overlying a left brachiobasilic fistula are spared. His vaccination record is unavailable.

In addition to standard precautions, which ONE of the following is the MOST appropriate management?

A. Cover the lesions and administer dialysis at the outpatient facility in a regular chair
B. Cover the lesions and administer dialysis at the outpatient facility in an isolation room under contact precautions
C. Transfer the patient to a tertiary care hospital after outpatient hemodialysis treatment
D. Immediately transfer the patient to a hospital for both airborne and contact isolation

5. Since the launch of the Nephrologists Transforming Dialysis Safety by the American Society of Nephrology with the support of the United States Centers for Disease Control and Prevention, you and your interdisciplinary team have made infection control a priority at your dialysis facility. The "Days Since Infection" Poster has been downloaded from the American Society of Nephrology website and has been prominently displayed in your unit. Before weekly dialysis rounds, you decide to inconspicuously observe dialysis staff performing hand hygiene.

In which ONE of the following situations is hand washing with soap and water preferred for dialysis staff over the use of alcohol-based hand rubs?

A. After inadvertently touching a hemodialysis machine
B. After documenting notes on a portable computer
C. After contact with a patient with a recent diagnosis of *Clostridium difficile*–induced diarrhea
D. Before preparation of medications for parenteral administration
E. Before changing the dressing covering the exit site of a central venous catheter (CVC)

6. A hemodialysis center has received notice from a state health agency regarding several infection control deficiencies, including poor compliance with recommended hand hygiene procedures that were observed during a recent on-site audit.

Which ONE of the following strategies is MOST likely to improve adherence of staff with recommended hand hygiene practices?

A. Encourage the staff to wash their hands with soap and water before and after each contact with a patient
B. Promote the frequent use of gloves during the dialysis procedure because hand hygiene is not necessary if gloves are worn during patient care
C. Make alcohol-based hand rub readily available near dialysis stations, and observe hand hygiene opportunities monthly, providing staff with feedback regarding their performance
D. Minimize the time needed for hand hygiene by training staff to apply a small amount of an alcohol-based hand rub for 10 seconds

7. An investigation is initiated at a hemodialysis clinic after it is discovered that six patients have acquired hepatitis C over a period of 1 year. Nucleotide sequencing analysis by the Centers for Disease Control and Prevention revealed high homology and close clustering of hepatitis C virus quasispecies among these patients. Multiple lapses in infection control practices at the dialysis center were identified.

Which ONE of the following infection control gaps has frequently been associated with outbreaks of hepatitis C virus infection in hemodialysis units?

A. Dialyzing hepatitis C-positive patients in the main area of the unit instead of dialyzing the patient using a dedicated room, machine, and equipment
B. Failure of personnel to change gloves and perform hand hygiene when moving between patients, between patients and potentially contaminated surfaces, and between machines
C. Poor compliance by staff with recommended use of gowns when caring for patients with open skin wounds with drainage not contained by dressings
D. Failure to adequately reprocess reusable dialyzers

8. Outbreaks of hepatitis C and, less frequently, hepatitis B and bacterial bloodstream infections in outpatient hemodialysis centers have often been due to poor adherence to infection control practices. Inappropriate handling and administration of parenteral medications in hemodialysis clinics pose an additional risk for the transmission of such pathogens.

Which ONE of the following medication injection safety measures minimizes the risk of blood-borne pathogen transmission in outpatient hemodialysis facilities?

A. Use a mobile cart to transport injectable medications to multiple patients
B. Prepare medications at the patient's dialysis station whenever possible
C. Avoid administration of medications from the same syringe to more than one patient
D. When using single-dose vials of medication, refrigerate vials containing residual (excess) medication before pooling for administration to subsequent patients.

9. You are making rounds with two first-year nephrology fellows at an outpatient dialysis clinic. The fellows ask you about the removal of endotoxins during water purification.

Which ONE of the following components of water purification should you instruct them is responsible for the removal of the majority of endotoxins before the final pass through endotoxin ultrafilters prior to feeding the distribution loop?

A. Water softener resin
B. Brine tank
C. Carbon medium
D. Reverse osmosis membrane

10. As medical director of a hemodialysis facility you are reviewing four possible occurrences with the care team that would necessitate disinfection of the internal hemodialysis components before the machine is used for the subsequent treatment.

Which ONE of the circumstances would warrant disinfection of the internal hydraulic components of the hemodialysis machine between treatments?

A. An air leak
B. A blood leak due to a ruptured dialyzer membrane
C. Completion of hemodialysis in a patient with hepatitis C virus infection
D. Completion of hemodialysis in a patient with HIV infection

11. A 62-year-old man who initiated hemodialysis is evaluated during weekly rounds. The charge nurse has placed the patient in isolation because the hepatitis B surface antigen returned positive on admission laboratory studies. A review of his record indicates that he had no prior history of hepatitis. Serologic studies performed 3 months ago as part of an evaluation for transplantation showed that the hepatitis B surface antigen, hepatitis B surface antibody, and hepatitis B core IgM were all negative. He is up to date on pneumococcal vaccination, received influenza vaccination several weeks ago, and received his first dose of hepatitis B vaccine 5 days ago. On physical examination, his vital signs are normal. He has no pallor or jaundice. The remainder of his physical examination results are normal. Laboratory studies show normal liver chemistries, normal prothrombin time, normal albumin, negative hepatitis B surface antibody, negative hepatitis B core IgM, and negative total hepatitis B core antibody.

Which ONE of the following is the BEST explanation of the positive hepatitis B surface antigen serologic result?

A. Acquired immunity from vaccination against hepatitis B virus
B. Prior hepatitis B virus infection
C. Acute hepatitis B infection
D. Recent exposure to hepatitis B vaccine

12. In your role as medical director of a dialysis facility you decide to observe dialysis staff during a shift change. A newly hired technician is observed taking a patient off dialysis. The technician is observed returning a patient's blood, followed by clamping of the arteriovenous lines. The lines are then disconnected from the dialysis machine. The technician places a nonsterile pad over the arterial site and removes the arterial needle while wearing nonsterile gloves. After hemostasis is achieved, a nonsterile gauze pad is placed on the arterial site. This same procedure is repeated for the removal of the venous needle. He then moves to

the next patient, dons a new set of gloves, and repeats the same takeoff procedure.

Which ONE of the following represents a breach in proper infection control practices?

A. Placement of a nonsterile gauze pad at the cannulation site
B. Failure to apply antibiotic ointment at the arterial or venous sites cannulation sites before placing the dressing
C. Failure to perform proper hand hygiene between patient encounters
D. Failure to use sterile gloves during decannulation

13. A recent continuous quality improvement analysis at your dialysis unit revealed that the frequency of CVC infections has recently risen to >1 per 1000 catheter days (equivalent to >3 per 100 patient-months). Current procedures include cleansing of exit sites with povidine-iodine and use of sterile gauze to cover the exit at each treatment. An antibiotic lock solution is currently being used in one patient with a history of recurrent catheter-related bloodstream infections (CRBSIs).

Which ONE of the following interventions is the next BEST step to reduce the frequency of CRBSIs in your unit?

A. Change sterile gauze to a transparent semi-permeable dressing after each treatment
B. Use an alcohol-based chlorhexidine (>0.5%) solution for cleansing the exit site skin, and scrub the hub with 70% alcohol
C. Use needle-free connectors for all CVC hubs
D. Use gentamicin-citrate lock solution in all patients
E. Use an alteplase lock solution in all patients

14. One afternoon, you enter the treatment area of your dialysis facility and notice fresh blood (about 30 ml) on the floor from a patient who experienced postprocedure bleeding from the access site. After appropriate measures are taken, the bleeding has subsided and the patient is clinically stable. You review the policy for cleaning and disinfection of blood spills as the staff proceed to clean the treatment area.

Which ONE of the following is the MOST appropriate method for removing blood on the floor?

A. Single application of soap and water
B. Double application of soap and water
C. Single application of tuberculocidal disinfectant
D. Double application of tuberculocidal disinfectant
E. Soap and water followed by tuberculocidal disinfectant

15. An outpatient hemodialysis facility's medical director became concerned upon receipt of the updated National Healthcare Safety Network Facility Rate Table. The table indicated that the facility's bloodstream catheter infection rate was significantly higher than the national average. The interdisciplinary team, under the leadership of the medical director, reviewed and analyzed data, including the results of CDC Infection-Related Audit Tools through the facility's Quality Assurance Performance Improvement program (QAPI). Deficiencies were found in the areas of hand hygiene, catheter connection and disconnection, dialysis station routine disinfection, and catheter exit site care. The medical director recommended corrective actions to improve the facility culture of safety rather than addressing each process individually.

Which ONE of the following BEST describes how medical directors can influence the culture of safety in dialysis facilities?

A. Develop action plans to improve infection control practices, explaining the rationale of each plan with provision of feedback on the plan's impact
B. Provide educational materials to both nephrology physicians and facility staff directed toward best infection prevention and control practices
C. Develop new policies and guidelines that are easier to understand compared with those currently being used
D. Ensure that error-prone staff members undergo disciplinary actions and re-education
E. Designate an individual among the facility staff who is charged with assuring proper infection prevention and control techniques throughout the facility

16. During a Quality Assessment and Performance Improvement (QAPI) meeting, the clinical

manager informs the medical director and dialysis team that the clinic has experienced an increased rate of bloodstream infections (BSI) and a high rate of CVC access use over the past 6 months.

Which ONE of the following BEST characterizes the expected role of medical director with regard to this clinical issue according to the United States Center for Medicare and Medicaid Services Conditions for Coverage for ESRD facilities?

A. Medical directors are responsible for the oversight of all care-related activities, including the high BSI and CVC rates at that facility
B. Medical directors manage the interdisciplinary team (IDT) for all patients, and the IDT evaluates the causes of high BSI and CVC rates
C. Medical directors should serve as the attending physician for all patients at their designated facility
D. The nurse manager is the clinician who oversees the QAPI program that would address the high infection rate

17. You are employed as a full-time nephrologist by a regional for-profit health care (HC) system that owns three local hospitals. The management team of this HC entity plans to open an outpatient dialysis facility in close proximity to their hospitals. You are asked to provide expertise in the design of the dialysis facility. Specifically, they ask your opinion about hemodialyzer reuse at the facility.

Which ONE of the following should you tell the management team about hemodialyzer reuse?

A. Infection risk with hemodialyzer reuse is equal to that of a single-use dialyzer
B. Gram-negative bloodstream infections have been reported with hemodialyzer reuse
C. Dialyzer reprocessing of reuse dialyzers is an easy-to-perform single-step procedure with the latest automated reprocessing machines
D. The current Association for the Advancement of Medical Instrumentation (AAMI) guidelines mandate a single specific step-by-step procedure for hemodialyzer reuse to minimize risks

18. Your dialysis facility technician and nurse manager contact you for recommendations after cultures from the last outlet of the distribution loop reveal a bacterial level of 300 colony forming units/ml. Hemodialysis is actively being performed during the receipt of the culture report.

Which ONE of the following is the MOST appropriate management?

A. Prescribe prophylactic antibiotics for the patients receiving hemodialysis
B. Immediately discontinue dialysis and order blood cultures
C. Decrease dialysate flow and blood flow rates to minimize diffusive exposure
D. Assess whether continuing dialysis is less detrimental than withholding treatment
E. Change to a different hemodialysis machine with new dialyzer and blood line

19. A 54-year-old woman receives maintenance hemodialysis treatments through a left internal jugular tunneled catheter. She has exhausted all other options for permanent dialysis access. Upon arrival for a scheduled hemodialysis treatment, she reports having fever and chills but no additional symptoms. On physical examination, the patient is in no acute distress. Her temperature is 38.6°C, her blood pressure is 140/86 mmHg, her heart rate 96/min, and her respiratory rate is 14/min. The catheter exit site is unremarkable, and the patient is alert and otherwise clinically stable. No peripheral veins are identified for peripheral blood cultures.

Which ONE of the following is the next BEST step in this patient's management?

A. Obtain two sets of blood cultures from the hemodialysis catheter before administering antibiotics
B. Obtain one set of blood cultures from the hemodialysis catheter and one set of blood cultures from the hemodialysis circuit, both before antibiotic administration
C. Cancel the scheduled dialysis treatment and send the patient to the emergency room for evaluation and management
D. Administer antibiotics immediately, then obtain two sets of blood cultures from the hemodialysis circuit–one from the arterial port and another from the venous port

20. A 47-year-old woman has ESRD resulting from lupus nephritis. One month ago, she transitioned to in-center hemodialysis from peritoneal dialysis because of ultrafiltration failure. Four days ago, she experienced a fever to 38.7°C, chills, and cough during a scheduled hemodialysis treatment. She did not have dyspnea or hypotension. Your nephrology partner requested blood cultures and ordered intravenous vancomycin. A chest radiograph showed a left lower lobe infiltrate. The oxygen saturation was 98% on ambient air, and the leukocyte count was 9600/μL. Two days later, the blood cultures return, showing methicillin-sensitive *Staphylococcus aureus* in both bottles that is sensitive to vancomycin, gentamicin, cefazolin, daptomycin, and linezolid. The patient has improved and is now afebrile. She has no known drug allergies.

Which ONE of the following is the MOST appropriate antibiotic regimen for this patient?

A. Continue vancomycin for at least 4 weeks and monitor trough levels
B. Add gentamicin after every dialysis treatment for synergy
C. Replace vancomycin with cefazolin to complete at least 4 weeks of antibiotics
D. Replace vancomycin with daptomycin to complete 4 weeks of antibiotics
E. Discontinue vancomycin and start oral linezolid to complete 4 weeks of antibiotics

21. A patient from your dialysis center with recently diagnosed vancomycin-resistant *Staphylococcus aureus* bacteremia is ready for hospital discharge. The patient has received 1 week of antibiotic therapy, and infectious disease consultants have recommended outpatient parenteral anti-infective therapy for several more weeks with daptomycin plus ceftaroline through a separate internal jugular vein access. There is one separate isolation room at your facility that is currently used to treat several patients with hepatitis B virus infection. As a result, the isolation room is not available for this patient.

In addition to strict adherence to standard infection control practices, which ONE of the following additional infection control measures should you recommend for this patient?

A. Dialyze the patient at a station with as few adjacent stations as possible
B. Inform the hospital to cancel the discharge because the patient needs inpatient isolation until she completes the antibiotic course
C. Recommend hand hygiene with soap and water for dialysis staff after contact with this patient
D. Recommend that staff wear reusable gowns when caring for the patient at all times

22. Which ONE of the following statements regarding antibiotic use in outpatient hemodialysis units in the United States is CORRECT?

A. Patients with CVCs have equivalent rates of intravenous antibiotic use compared with patients with arteriovenous fistulas and grafts
B. First-dose antimicrobial therapy in hemodialysis units accounts for the highest proportion of inappropriate intravenous antibiotic use
C. Over 60% of patients using long-term hemodialysis receive at least one dose of intravenous antibiotics each year
D. Vancomycin is the most commonly prescribed intravenous antibiotic

23. A 40-year-old man receiving maintenance hemodialysis is found to have methicillin-resistant *Staphylococcus* bacteremia after presenting to the dialysis unit with fever. He has a mature arteriovenous fistula that is cannulated by staff using the "buttonhole" technique. Examination of the arteriovenous fistula shows no erythema, tenderness, or purulent discharge from the cannulation sites. The results of his physical examination are otherwise normal. An echocardiogram and magnetic resonance images of the spine are normal. He is treated with vancomycin for 4 weeks, with resolution of his fever. He had a similar episode 6 months ago.

Which ONE of the following is the BEST strategy to prevent recurrent bloodstream infections in this man?

A. Culture his nares and treat with intranasal mupirocin if the culture grows *Staphylococcus aureus*
B. Evaluate the processes of care in the dialysis facility such as wearing masks, washing hands, and using antiseptics and gloves when accessing the fistula

C. Switch to the "rope ladder" for needle placement in the fistula
D. Focus on patient hygiene such as showering and washing the fistula arm with soap and water before each dialysis treatment
E. Obtain surveillance blood cultures from the fistula at monthly intervals, and treat when the results are positive

24. The medical director of a dialysis unit has oversight of the infection prevention and control program. In putting together the infection prevention and control plan you highlight the essential components and resource requirements of the program during a monthly Quality Assessment and Performance Improvement meeting.

Which ONE of the following is an essential component of the infection prevention and control program within a dialysis facility?

A. Infection surveillance and use of infection rate data to drive prevention
B. One full-time staff person who is in charge of the infection control program
C. Hiring an epidemiologist to investigate bloodstream infections
D. Use common medication carts to deliver medications to patients

25. Water supplies may be contaminated or disrupted during a natural or civil emergency. Medical directors are often called to determine best options for the outpatient hemodialysis facility when these occur.

Which ONE of the following statements is TRUE about managing potentially contaminated dialysis water supplies in the event of a natural disaster?

A. A tanker truck that has been repurposed from hauling vegetable oil for transporting water is an acceptable source of water for hemodialysis pretreatment systems
B. Water transported by tanker trucks to dialysis facilities should not be chlorinated before the beginning of the haul
C. Water from a well deeper than 30 meters is considered a safe water supply for hemodialysis after a hurricane or flooding
D. During a "Boil-Water Advisory," dialysis water treatment systems that rely on deionization units can be used without additional modifications

26. An outpatient hemodialysis facility receives an immediate jeopardy citation from a Medicare surveyor after repeated violations are discovered in infection control involving repeated cross-contamination of medical supplies and improper disinfection of treatment surfaces. The facility has previously been cited for poor infection control. Interviews with numerous facility staff, including the medical director, suggest a widespread lack of individual accountability and a tendency to blame others for problems in the unit.

Which ONE of the following issues BEST describes the fundamental problem at this facility?

A. Outdated infection control policies
B. Inadequate staffing
C. Poor patient and staff understanding of hand hygiene
D. High community incidence of healthcare-acquired infections
E. Lack of an effective culture of safety

27. During a review of cultures of dialysate at your hemodialysis center, you note a bacterial concentration of >50 colony-forming units/ml (CFU/ml).

In addition to ongoing retesting, which ONE of the following is the MOST appropriate next step in management?

A. No additional measures are required
B. Withhold dialysis treatments at the center until the bacterial counts are <25 CFU/ml
C. Perform chemical disinfection
D. Replace the reverse osmosis membrane

28. A 70-year-old man receiving maintenance hemodialysis is seen on dialysis rounds. Pruritic nodules have developed on his trunk and extremities. His primary care physician prescribed a topical corticosteroid cream that has helped with the pruritus, but the nodules continue to reappear. A physical examination shows linearly arranged 3- to 5-mm hyperpigmented nodules with excoriation. His partner has had similar symptoms. You suspect that the lesions are due to bedbug bites.

In addition to symptomatic treatment with topical corticosteroids and oral antihistamines, which ONE of the following is the MOST appropriate management?

A. Dialyze the patient at the far end of the room, and restrict the chair solely for that patient's use
B. Implement no additional environmental measures at the dialysis facilities
C. Make a mandatory assignment of the patient to an isolation room
D. Use a single 8- to 10-hour application of permethrin 5% cream on the entire body

29. As the medical director you receive a call from an attending nephrologist at your dialysis unit. This nephrologist reports that a 10-year-old patient has received a diagnosis of an active infestation of pediculosis capitis.

In addition to thorough bathing and heat washing of the patient's affected clothes and linens and use of a topical pediculicide, which ONE of the following is the MOST appropriate management?

A. Use extra care in the terminal cleaning of the dialysis station, with special attention to the dialysis chair after the patient has completed the dialysis treatment
B. Examine all patients in the facility for head lice because lice may survive for weeks on dialysis equipment and chairs
C. Institute daily hair washing with a shampoo/conditioner or conditioner before and after application of a topical pediculicide
D. Prescribe lindane shampoo for the affected patient

30. You are paged by a nurse from a hemodialysis facility you are covering about an 81-year-old woman with ESRD due to polycystic kidney disease, along with mild cognitive impairment. Her spouse has noted that she has not been eating well for the past 3 days. She has been more confused than usual and has complained of "feeling hot." The patient has no other specific complaints and is oriented to place and person. She is not taking any new medications. Her temperature is 37.3°C, her pulse is 96/min and regular, and her blood pressure is 102/80 mmHg. The patient is in no respiratory distress but is mildly tachypneic, with a respiratory rate of 22/min. The oxygen saturation is 92% on ambient air. Her weight is equal to the estimated dry weight. The nurse hears crackles at both lung bases. There is no leg edema. The arteriovenous fistula has no erythema or fluctuance.

Which ONE of the following is the next BEST step in this patient's management?

A. Review the patient's baseline vital signs
B. Order a 500-ml bolus of intravenous normal saline
C. Lower the patient's target weight by 1 kg
D. Order empiric vancomycin and ceftriaxone