



Hand Hygiene in Haemodialysis Units

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Abstract

Healthcare-associated infections are a major risk to patient safety. Infection is the first cause of hospitalisation and the second most common cause of mortality among haemodialysis (HD) patients. HD patients, as well as the dialysis staff, are vulnerable to contracting healthcare-associated infections due to frequent and prolonged exposures to many possible contaminants in the dialysis environment. The extracorporeal nature of the therapy, the associated common environmental conditions, and the immune compromised status of HD patients are major predisposing factors. HD patients are exposed to different types of infections which include bloodstream infections and localized infections of the vascular access, blood-borne infections with hepatitis B virus, hepatitis C virus, and/or human immunodeficiency virus, and airborne infections. Sources of infections include contaminated water, equipment, environmental surfaces, and infected patients. The evident increased potential for transmission of infections in the HD settings led to the creation and implementation of specific and stricter infection prevention and control measures in addition to the usual standard precautions. Contaminated hands of healthcare workers are among the most common modes of transmission of healthcare-associated infections. Hand hygiene is singled out as the most important infection prevention intervention. Hand hygiene compliance can be improved by continuous education and monitoring, providing a sufficient number of sinks with soap dispensers, paper towels, hand lotions and alcohol-based hand rub placed at each patient station, and regular feedback of surveillance results. Education and training and full awareness of infection control policies and procedures should be provided to all Healthcare workers and to be repeated regularly. The patient and/or caregiver should also be educated on hand hygiene and the care of new vascular access.

Keywords

Hand, Hygiene, Haemodialysis, Healthcare, Infection, Vascular Access

Subject Areas: Infectious Diseases, Nephrology

1. Introduction

Healthcare-associated infections are a potential risk to patient safety and constitute a major cause of morbidity

and mortality. In healthcare settings, there are three major types of healthcare-associated infections: surgical-site infections, central-line-associated bloodstream infections, and catheter-associated urinary tract infections. In dialysis units, infection is the first cause of hospitalization and the second most common cause of mortality among haemodialysis (HD) patients after cardiovascular disease [1]-[3]. HD patients are exposed to different types of infections which include bloodstream infections and localized infections of the vascular access (catheters and grafts), blood-borne infections with hepatitis B virus (HBV), hepatitis C virus (HCV), and/or human immunodeficiency virus (HIV), and airborne infections like tuberculosis. Sources of infections could be contaminated water, equipment, environmental surfaces in the treatment area, and patients with infections who pose a risk to other nearby patients being treated in the dialysis unit. The increased risk for contracting healthcare-associated infections (HAIs) among HD patients are mainly due to 1) immune compromised status, 2) frequent and prolonged blood exposure during HD treatments through the vascular access and extracorporeal circuit (with many ports and connections), 3) close proximity to other patients during treatment in the HD facility, 4) frequent contact with healthcare workers who frequently move between patients and between machines, 5) frequent hospitalization and surgery, and most importantly 6) non-adherence or a break in implementation of recommended practices, including hand hygiene and use of personal protective equipment.

The break in implementation of recommended practices may sometimes occur inevitably as a result of one or more of the following factors: 1) understaffing with poor nurse to patient ratio [4]-[6], 2) frequent turn-over of nursing staff [4]-[9], 3) lack of or inadequate training and lower level of competency among HD staff [5] [9]-[11], 4) inadequate or lack of patient/family education, 5) inadequate provision of necessary supplies/equipment, including adequate clean sinks and/or alcohol-based hand rubs, soap and towels [10] [11], 6) poor design of HD unit lay-out (congested and inadequate segregation/isolation) [11], and 7) the urgency associated with dialysis complications (sometimes life-threatening situation) which may sacrifice adherence to standard precautions [9] [12] [13].

Healthcare Infection Control Practices Advisory Committee (HICPAC) and Centers for Disease Control and Prevention (CDC) recommended two-level approach precautions to prevent the transmission of infectious agents in healthcare settings. These are 1) Standard Precautions and 2) Transmission-Based Precautions. *Standard Precautions* are the basic level of infection control practices to be applied in the care of all patients and in all healthcare settings, regardless of the suspected or confirmed infection status. *Standard Precautions* were based on the principle that all blood, body fluids, secretions, excretions (except sweat), non-intact skin, and mucous membranes may contain transmissible infectious agents [14]. The elements of *Standard Precautions* include: 1) hand hygiene, 2) use of personal protective equipment (PPE) such as gloves, gown, mask, eye protection (eye goggles or face shield), and 3) handling of equipment or items including surfaces in the patient environment in a manner that prevent transmission of infectious agents. CDC added new elements to be considered as a standard of care which include: a) respiratory hygiene/cough etiquette; b) safe injection practices; and c) use of masks for insertion of catheters [14].

Transmission-Based Precautions are usually applied for patients who are known or suspected to be infected or colonized with infectious agents, including certain epidemiologically important pathogens that require additional control measures to effectively prevent transmission. *Transmission-Based Precautions* have three categories: 1) contact precautions, 2) droplet precautions, and 3) airborne precautions [14].

In addition to *Standard Precautions* and *Transmission-Based Precautions*, CDC recommended more stringent measures for HD settings, which include non-sharing of supplies, instruments, medications and medication trays between patients, and prohibit the use of a common medication cart [15]-[18]. Unlike the conditions in general hospital wards, the typical lay-out and associated conditions in most HD units (wherein *multiple patients* receive *extracorporeal treatment with prolonged blood exposures* in the *same area* and usually with *one healthcare worker (HCW) caring for more than one patient at the same time*) are potential factors that may increase the transmission of infections. Therefore, strict implementation of *Standard Precautions* and in particular hand hygiene constitutes an essential measure of infection prevention and control. The aim of this narrative review is to mainly focus on hand hygiene and other related *Standard Precautions* in a HD facility, where the importance of implementation of such precautions is shared with other healthcare settings. Other more specific hemodialysis-related infection control measures, which include cleaning and disinfection of HD machine's external surfaces, disinfection of internal fluid pathway of HD machines, handling of disposable supplies and reusable items in HD units, purity and testing of treated water, screening and routine serologic testing and patient placement, and immunization of patients and healthcare personnel are all reviewed in [19].

2. Hand Hygiene

Contaminated hands of HCW are among the most common modes of transmission of healthcare-associated infections. Pittet and colleagues [20] described a five-step sequence resulting in microbial transmission through contaminated hands during healthcare delivery. These are “1) pathogens shed by infected patients can contaminate surrounding environments, 2) HCW’s hands get contaminated by contact with patient skin or surrounding environment, 3) pathogen remains viable on the HCW’s hands for at least several minutes 4) HCW may omit hand decontamination or use inappropriate product or procedure, and 5) HCW’s contaminated hands can either transfer the pathogen directly to another patient or indirectly on a medical device or objects within the patient’s immediate vicinity”.

Different studies have confirmed that transiently contaminated hands of the HCW are the main route of transmission of healthcare-associated infections [21]-[29]. Hand hygiene, therefore, is singled out as the most important infection prevention intervention. However, the compliance rates of HCWs in hand hygiene is very poor, with an overall average of 40% or less [30] [31]. Based on hand hygiene indications per recommendations from Association for Professionals in Infection Control and Epidemiology (APIC) [32], CDC [15] and World Health Organization (WHO) [33] (Table 1), the estimated number of times a single dialysis staff is required to perform hand hygiene per HD session per patient is shown in Table 2. The estimated number can be a minimum of 60 to 100 times when multiplied by the number of patients assigned per staff (e.g., 2 - 3 patients). The large number of times an HD staff is required to perform hand hygiene could be a reason for lack of compliance. However, compliance can be improved by continuous education, supervision and monitoring of hand hygiene behaviors, where the latter represents the most effective method in improving performance [34].

Monitoring hand hygiene compliance is crucial and direct observation is the current gold standard method. However, direct observation has several limitations, among which are being labor intensive, small sample size (may cover only 1% of total hand hygiene activity), and not standardized. A new model device application developed by the *Computational Epidemiology Research Group at the University of Iowa* (the “iScrub Lite”, which is available for free download on the Apple iTunes store for Apple® iPhone or iPod), can facilitate the work of the Infection Preventionist (IP) by recording the observations, which can be loaded to an excel spreadsheet for ready analysis. Advanced technologies, with automated electronic devices and software (Real Time Location System), can monitor the number of hand hygiene activity (10 to 50 thousands per month) in each department, floor or unit, and identify the HCW performing the hand hygiene through badge or wristband detection, with indication of the time of day and day of the week hand hygiene is performed, and even provide feedback/cueing to encourage proper hand hygiene [35].

Compliance can also be improved by providing, in convenient locations, a sufficient number of sinks with

Table 1. Hand hygiene indications as recommended by APIC, CDC, and WHO.

APIC [32]	CDC [15]	WHO-“My Five Moments for Hand Hygiene” [33]
1. Just before touching a patient	1. Before touching a patient, even if gloves will be worn	1. Before touching a patient
2. After touching blood, body fluids, secretions, excretions and contaminated items (including front of the HD machine)	2. Prior to performing an aseptic task (e.g., placing an IV, preparing an injection)	2. Before clean/aseptic procedure
3. Before leaving a patient station	3. After contact with blood, body fluids, excretions, or wound dressings	3. After body fluid exposure risk
4. Before accessing or restocking supplies	4. Before exiting the patient’s care area after touching the patient or the patient’s immediate environment	4. After touching a patient
5. After gloves are removed	5. If hands will be moving from a contaminated-body site to a clean-body site during patient care	5. After touching patient surroundings
	6. After glove removal	

APIC = Association for Professionals in Infection Control and Epidemiology, CDC = Centers for Disease Control and Prevention, WHO = World Health Organization.

Table 2. Estimated minimum number of times where hand hygiene is required per dialysis session per patient [19] (regardless of gloves use).

SN	Activity	Before	After	Total
1	Accessing supplies from common clean storage area	1	-	1
2	Preparing/setting-up the HD machine	*	1	1
3	Preparing/administering medications (including for anticoagulation)	1	1	2
4	Pre-dialysis: measuring vital signs/weighting	*	1	1
5	Preparing trolley/tray for cannulation	*	1	1
6	Palpating clean cannulation sites	*	1	1
7	Skin preparation & cannulation of arteriovenous access (AVF, AVG)	*	1	1
8	Preparing trolley for catheter dressing**	*	1	1
9	Removing old dressing over catheter site**	-	1	1
10	Catheter exit site dressing**	*	1	1
11	Connection for HD	1	1	2
12	Handling blood samples and other specimens	-	1	Minimum 1
13	Checking blood pressure (every 1/2 - 1 hour for 4 hours)	1	1	Minimum 8
14	Catheter/blood lines manipulation	1	1	Minimum 2
15	Adjusting machine parameters and/or attending machine alarms	-	1	Minimum 1
16	Attending to patient's incidents/assisting patient	1	1	Minimum 2
17	Prepare trolley for dialysis disconnection	1	-	1
18	Disconnection of HD	1	1	2
19	Post-dialysis: measuring vital signs/weighting	*	1	1
20	Cleaning/disinfection of dialysis equipment	*	1	1
21	Leaving the dialysis unit	1	-	1
Total estimated minimum number of times hand hygiene is required per dialysis per patient				~30

*Most of the time, the activity is recently preceded by a hand hygiene performed at the end of one procedure/activity (between two different activities). Therefore, repetition of hand hygiene prior to an activity (wherein performance of hand hygiene is indicated per recommendation) is unnecessary.

**Not included for patients with permanent arteriovenous (AV) access.

soap dispensers, paper towels, hand lotions (e.g., one for every 2 - 4 dialysis station), and alcohol-based hand rub (ABHR) placed at each patient station [32]. Because of the proven superior efficacy in decontamination, better skin tolerability and ease of use, ABHR is recommended to be used in all clinical situations if hands are not visibly soiled. If exposure to bacterial spores (*i.e.*, bacillus anthracis and/or clostridium difficile) is suspected or proven, hand washing with soap and water is recommended, because spores are resistant to most antiseptic agents and requires physical removal by washing and rinsing [36]. Other preventive measures include restriction of having long nails and wearing of artificial fingernails or extenders by healthcare personnel who provide direct patient care, as artificial nails could harbor gram negative bacilli and yeasts [30] [32] [36]-[40].

3. Personal Protective Equipment

Personal Protective Equipment (PPE) refers to a variety of barriers and respirators used alone or in combination to protect mucous membranes, airways, skin, and clothing from contact with infectious agents, which includes: gloves, gowns, masks, eye goggles, face shields, and respirators [36]. In the HD setting, gloves are recommended to be worn whenever caring for a dialysis patient; whether touching patient's intact skin (e.g., taking blood pressure) or patient's equipment at the dialysis station. Gloves should be removed and followed by hand hygiene between patients or stations [16] [32]. The recommended practice of glove use for every contact with the patient(s) and equipment(s) at the dialysis station requires an enormous amount of glove supply, which is not al-

ways realistic in many HD units. However, when visible soil is present and/or contact precautions are indicated, wearing gloves is a must. Sterile gloves must be used during procedures requiring sterile aseptic technique, such as during catheter insertion or at any time a dialysis catheter is handled/manipulated [41]-[43]. Wearing gown (fluid-resistant with full coverage of the arms and body front and preferably disposable ones) over the uniform, and use of face mask and eye goggles or face shield is recommended when performing procedures wherein splashes of blood can be anticipated, especially during initiation and discontinuation of dialysis [16] [32] [36]. If a face shield is used during catheter handling, a surgical mask should be worn underneath to protect patient from HCW's respiratory droplets [32]. Equally important is that patient should also wear a mask and asked to turn his/her face away from the catheter site to reduce contamination from infectious droplets [32] [43]-[45]. Furthermore, wearing a mask is important when a staff member, a patient or a visitor is experiencing cold or cough [32] [36]. A respirator should be used by HCWs only when taking care of a patient with an airborne infection. HCWs uniforms can be colonized with potentially pathogenic bacteria for up to 60% [46]-[51] and therefore should be laundered and changed daily in order to decrease the bacterial load.

4. Cleaning and Disinfection of Environmental Surfaces

In the healthcare setting, contamination of environmental surfaces with various pathogens and the persistence of these pathogens on surfaces [52]-[58] can be an important and frequent source of transmission of infectious agents through the frequent hand touching of HCWs [59] [60]. The environment in HD units is particularly prone for contamination with blood-borne pathogens such as HBV, HCV and HIV, and other infectious agents such as methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant Enterococci (VRE), and *Clostridium difficile* (*C. difficile*). Microorganisms can survive on environmental surfaces for varying periods of time ranging from few hours to days and months. Low temperature, high humidity and high inoculums favor the long persistence of pathogens on inanimate surfaces [52]. In order to prevent and control spread of environmentally transmitted pathogens, cleaning and disinfection of the external surfaces of equipment (*i.e.*, HD machine, dialysis chair or bed, procedure trolley) and other environmental surfaces inside HD units, especially those that are frequently touched by patients and staff, should be performed between all patient treatments (irrespective of the patient diagnosis) [16] [32] [43]. The application of *friction* during cleaning is emphasized since some organisms like *C. difficile* are not easily inactivated by most surface disinfectants (except bleach) and require removal by friction [32] [36].

5. Cleaning and Disinfection of Auxiliary Equipment

Auxiliary equipment used in HD may include reusable jugs for mixing bicarbonate solution, reusable priming buckets, and external pressure transducers. As per recommendation, any reusable item should be cleaned and disinfected prior to being used on another patient, and external pressure transducers should be changed between patients' uses. Nowadays, many units have shifted to use the more hygienic automated process of mixing bicarbonate powder in cartridge on the individual machines eliminating the use of reusable bicarbonate jugs. If bicarbonate solution in a jug is used, any "left-over" solution must be discarded and opened jugs should not be used after 24 hours because sodium bicarbonate solution substitute a good media for bacterial growth [32]. Reusable priming buckets are now seldom used since most dialysis companies include a disposable prime collection bag in each pack of sterile bloodline set, and also with pre-attached external pressure transducers. With improved and better technology in some latest model of HD machines, prime collection bags or transducer protectors are not even required, because drainage of priming solutions can be done by connecting the bloodline to a drainage port in the machine, and blood pressure sensors are completely non-invasive without using transducer connections and protectors.

6. Handling of Disposable Supplies and Reusable Items in HD Units

Both CDC and APIC recommended specific measures which include the following: 1) items taken into an individual patient's HD station should be used only for that patient and be disposed of after use, 2) unused item(s) should be cleaned and disinfected before returning to a common clean area or used on another patient, or be disposed of if it cannot be disinfected, and 3) non-disposable items that cannot be comprehensively cleaned and disinfected (e.g., adhesive tape, cloth-covered blood pressure cuffs) should be dedicated for use on a single pa-

tient [16] [32]. In reality, allocating a blood pressure cuff for each patient may not be practical as too frequent detachment and re-attachment of the cuff can cause imminent damage to the line connections. Reusable blood pressure cuffs that are covered with waterproof material with smooth surface (instead of cloth-covered cuffs) can be an attractive alternative, as they can be comprehensively cleaned and disinfected between patient uses. There should also be a clear separation for storage and handling of clean supplies and medications from contaminated items (*i.e.*, used supplies/equipment, blood samples, biohazard containers).

7. Safe Injection Practices

Aside from the basic principles of aseptic technique, there are specific complementary recommendations for HD published by the CDC and APIC, which include the following: 1) all single-use injectable medications and solutions should be dedicated for use on a single patient and be entered one time only, 2) medications packaged as multi-dose should be assigned to a single patient whenever possible, 3) medication preparation should occur in a clean area away from the patient treatment area, and be delivered separately for each patient, 4) not to carry multi-dose vials from station to station or carry medication vials, syringes, alcohol swabs or supplies in pockets, 5) unused medications or supplies taken to the patient's station should be used only for that patient and should not be returned to a common clean area or used on other patients, 6) not to use common medication carts to deliver medications to patients, and if trays are used to deliver medications to individual patients, they must be cleaned between patients [16] [32] [61]. CDC's full recommendations on safe injection practices are shown in **Table 3**.

8. Vascular Access: Care and Prevention of Infection

Infection rates with tunneled dialysis catheters has been estimated to be 10 times higher than that of arteriovenous fistula (AVF) or AV graft [32], and found to be the leading risk factor of bacteremia in chronic HD patients [62]. The international bodies are in concert with the guidelines that vascular access should be a native AV fistula whenever possible, AV graft as the next preferred option, and the use of catheters to be avoided as much as possible [17] [32] [42]-[45]. Vascular access infection prevention measures unanimously recommended by the international bodies are outlined in **Table 4**, and varying messages on dialysis catheter recommendations are outlined in **Table 5**. The relevance of "rubbing and soaking the catheter hub with the cap on with a povidone iodine swab for 3 - 5 minutes before the cap is removed" (as recommended by KDOQI) is understandably to disinfect the outside surface thereby preventing inadvertent contamination of the inner hub and ultimate bloodstream contamination. In the 2011 update of CDC Guidelines for the Prevention of Catheter-Related Infections,

Table 3. Key recommendations on safe injection practices in ambulatory care settings.

SN	Recommendations
1	Use aseptic technique when preparing and administering medications
2	Cleanse the access diaphragms of medication vials with 70% alcohol before inserting a device into the vial
3	Never administer medications from the same syringe to multiple patients, even if the needle is changed or the injection is administered through an intervening length of intravenous tubing
4	Do not reuse a syringe to enter a medication vial or solution
5	Do not administer medications from single-dose or single-use vials, ampoules, or bags or bottles of intravenous solution to more than one patient
6	Do not use fluid infusion or administration sets (e.g., intravenous tubing) for more than one patient
7	Dedicate multidose vials to a single patient whenever possible. If multidose vials will be used for more than one patient, they should be restricted to a centralized medication area and should not enter the immediate patient treatment area (e.g., operating room, patient room/cubicle, patient HD station)
8	Dispose of used syringes and needles at the point of use in a sharps container that is closable, puncture-resistant, and leak-proof
9	Adhere to "national" requirements for protection of HCW from exposure to blood borne pathogens

Content source: CDC. Guide to Infection Prevention for Outpatient Settings: Minimum Expectation for Safe Care. <http://www.cdc.gov/HAI/pdfs/guidelines/standards-of-ambulatory-care-7-2011> [15].

Table 4. Common recommendations on vascular access infection prevention.

Vascular Access Infection Prevention Measures	References
<i>Catheter insertion:</i> (Not addressed in KDOQI 2000/2006 guidelines)	
<ul style="list-style-type: none"> Avoid the use of femoral veins in adult patients Catheters should be inserted under strict aseptic technique Maximal barrier precautions (use of mask, cap, sterile gown and sterile gloves by the inserter, and large sterile drape to cover the patient) 	[17] [32] [41] [17] [32] [41]-[43] [17] [32] [43]
<i>Catheter care:</i>	
<ul style="list-style-type: none"> Only trained dialysis staff should perform catheter dressing changes and catheter manipulations The catheter exit-site should be examined for proper position and absence of infection by experienced personnel before accessing the bloodstream at each HD session Aseptic technique should be used to prevent contamination of the catheter system Use of a surgical mask for staff and patient for all catheter system connect, disconnect, and dressing procedures Catheter manipulation should be kept at a minimum 	[17] [32] [43]-[45] [17] [32] [41] [44] [45] [17] [32] [41] [43] [44] [32] [43] [44] [32] [43] [44]
<i>Skin preparation technique for permanent AV access:</i>	
<ul style="list-style-type: none"> The patient's access arm should be washed with antimicrobial soap and water prior to skin preparation with antiseptic solution To locate and palpate the needle cannulation sites prior to skin preparation To cleanse the skin by applying antiseptic solution before cannulation (alcohol-based chlorhexidine, or 10% povidone iodine solution and/or 70% alcohol) 	[32] [43]-[45] [32] [43]-[45] [32] [43]-[45]

KDOQI = Kidney Disease Outcomes Quality Initiative.

scrubbing of the access port with an appropriate antiseptic (chlorhexidine, povidone iodine, an iodophor, or 70% alcohol) was recommended for *needleless intravascular catheter systems* [17]. The routine scrubbing of dialysis catheter hubs (after cap removal before accessing, and before replacing a new cap) with an appropriate antiseptic was included as part of a recent CDC' score interventions for dialysis bloodstream infection (BSI) prevention (Table 6) [18]. Dialysis providers are cautioned to avoid introduction of the used antiseptic solution into the bloodstream [63]. In an *in vitro* study by Salzman *et al.* [64], the potential for the antiseptic used in cleaning the open catheter hub as well as few strands of cotton fibers to enter the bloodstream (simulated), and the effectiveness of normal saline solution (used as control) to reduce the microbial load at a level greater than 99% of the total number of microorganisms (suggesting mechanical removal) was demonstrated. The *cumulative effect* of minute residues of toxic antiseptics and foreign substance that may get into the patient's bloodstream when applied *repeatedly* on *open catheter hubs* among chronic HD patients have not, and may not be studied. Therefore, it is prudent to choose a *safe and non-toxic solution* for cleaning open catheter hubs and to emphasize the application of *friction* while cleaning (*scrubbing* not just wiping).

Since HD patients are more immune compromised than other surgical patients, pre-surgical infection prevention measures are recommended, which include: 1) pre-surgical shower/bath with an antiseptic agent such as chlorhexidine, the night before and morning of surgery, 2) if hair removal is necessary, to use clippers instead of razors to prevent infection associated with micro-abrasions resulting from razor use, and 3) avoiding intravenous placements and phlebotomy in the arm where access is to be placed (helps prevent infection and maintains vasculature integrity) [32]. Screening and decolonization for MRSA before an elective surgery may be used as an additional measure.

9. Tracking Infections

Surveillance for infections (outcome measures), and monitoring adherence to recommended infection prevention practices (process measures) are important components of an infection prevention program [65]. To enable safety, accurate comparison and analyses of monthly rates within the same facility, or meaningful benchmarking with other units/centers, it is important that a standardized and validated surveillance protocol be used uniformly by all dialysis facilities [66] [67]. A centralized surveillance system for healthcare-associated infections like the CDC's national healthcare safety network (NHSN) which requires all participating facilities to strictly follow very specific surveillance criteria, can provide accurate and reliable data that can be used to identify problem areas as well as measure progress of prevention efforts. Implementation of CDC's NHSN Dialysis Event Protocol (accessible online: www.cdc.gov/nhsn/dialysis) by other dialysis facilities outside the United States have

Table 5. Varying messages on catheter-related infection prevention strategies.

NKF/KDOQI	EBPG/ERBP	APIC	CDC
<i>Chlorhexidine for skin antisepsis</i>			
<p>“Chlorhexidine 2% with 70% alcohol is the preferred solution for cleansing of long-term catheter sites. For patients with sensitivities to chlorhexidine 2% with 70% alcohol, chlorhexidine aqueous may be used instead. For patients with sensitivities to chlorhexidine aqueous, povidone solution may be used.” [44]</p>	<p>The importance of <i>skin antisepsis before catheter placement</i> is indicated without mention of preferred antiseptic solution [41]</p>	<p>“For patients older than 2 months, a skin preparation solution containing >0.5% chlorhexidine gluconate and 70% isopropyl alcohol should be applied to the insertion site and allowed to dry before the skin is punctured.” [32]</p>	<p>“Use an alcohol-based chlorhexidine (>0.5%) solution as the first line skin antiseptic agent for central line insertion and during dressing changes. Povidone-iodine (preferably with alcohol) or 70% alcohol are alternatives for patients with chlorhexidine intolerance” [18]</p>
<i>Technique for all connect, disconnect, dressing procedures, catheter manipulations</i>			
<p>Clean aseptic technique (use of clean gloves) [44]</p>	<p>Sterile aseptic technique (use of sterile materials) [41]</p>	<p>Clean aseptic technique (use of clean gloves) [32]</p>	<p>“Wear either clean or sterile gloves when changing the dressing on intravascular catheters” [17]</p>
<i>Soaking and cleansing the catheter hub connection site with the cap on, with an antiseptic pad/swab</i>			
<p>“Cleanse <i>hub connection site and cap</i> vigorously with the first swab” [44]. “The catheter hub caps or bloodline connectors should be soaked for 3 - 5 minutes in povidone iodine and then allowed to dry prior to separation” [45]</p>	<p>Not mentioned in ERBP 2010 position statement on diagnosis, prevention and treatment of haemodialysis CRBSI, and in 2007/2002 guidelines [41]-[43]</p>	<p>“The hub of HD catheters can be soaked in povidone-iodine solution or wrapped with gauze saturated with povidone-iodine solution for 5 minutes prior to removing the caps” [32]</p>	<p>Not mentioned in CDC/HICPAC guidelines/recommendations [16] [17]</p>
<i>Disinfection of catheter hub after cap removal</i>			
<p>Not mentioned in 2000 Vascular Access Guidelines and in 2006 update [44] [45]</p>	<p>Not mentioned in ERBP 2010 position statement on diagnosis, prevention and treatment of haemodialysis CRBSI, in 2007 and 2002 vascular access guidelines [41]-[43]</p>	<p>“After removing the cap, the hub should be wiped with chlorhexidine, alcohol, or povidone iodine” [32]</p>	<p>“Scrub catheter hubs with an appropriate antiseptic after cap is removed and before accessing. Perform every time catheter is accessed or disconnected” [18]</p>
<i>Catheter exit-site dressing</i>			
<p>“Changing the catheter exit-site dressing at each HD treatment, using either a transparent dressing or gauze and tape” [44] “Use of dry gauze dressing... at the catheter exit-site are recommended after catheter placement and at the end of each dialysis session” [45]</p>	<p>“With long-term catheters, gauze is the preferred choice. The catheter exit-site should be covered by a dressing as long as the catheter remains in place. The exit-site should be inspected at every HD session, and the exit-site dressing should be replaced on a routine basis if it is no longer clean or intact” [41]</p>	<p>“The catheter exit-site dressing should be changed every 3 days (after each HD session) if gauze/tape, or every 7 days if transparent dressing is used in addition to whenever the dressing is wet or soiled” [32]</p>	<p>“Use either sterile gauze or sterile, transparent, semipermeable dressing. Replace dressings on short-term CVC sites every 2 days for gauze dressings, and every 7 days for transparent dressings. Replace transparent dressings on tunneled or implanted CVC sites no more than once per week (unless the dressing is soiled or loose), until the insertion site has healed” [17]</p>
<i>Application of antimicrobials or antiseptics on the catheter exit-site</i>			
<p>“...combined with skin disinfection using povidone iodine ointment or mupirocin ointment at the catheter exit site are recommended after catheter placement and at the end of each dialysis session” [45] Not mentioned in 2006 update [44]</p>	<p>“Application of antibiotic ointment at the exit-site should be considered after catheter placement until site has healed but should be discontinued after healing” [41]</p>	<p>Recommended routine application of povidone iodine or triple antibiotic ointment at the time of dressing change [32]</p>	<p>“Use povidone iodine antiseptic ointment or bacitracin/gramicidin/polymixin B ointment at the hemodialysis catheter exit site after catheter insertion and at end of each dialysis session only if this ointment does not interact with the material of the HD catheter per manufacturer’s recommendation” [17]</p>

Continued

<i>Antibiotic lock prophylaxis</i>			
No recommendation for routine prophylactic use [44] [45]	Preventive use is advocated to reduce the risk of CRBSI, but with caution to balance the benefits against the associated risk, and should not replace hygienic standards with regard to catheter care and handling [41]	Prophylactic use of antimicrobial catheter locking solution as a “plus measure”-unresolved issue [32]	“Use prophylactic antimicrobial lock solution in patients with long term catheters who have a history of multiple CRBSI despite optimal maximal adherence to aseptic technique” [17]

KDOQI = Kidney Disease Outcomes Quality Initiative, EBPG/ERBP = European Best Practice Guidelines/European Renal Best Practice, APIC = Association for Professionals in Infection Control and Epidemiology, CDC/HICPAC = Centers for Disease Control and Prevention/Healthcare Infection Control Practices Advisory Committee.

Table 6. The CDC core interventions for dialysis bloodstream infection (BSI) prevention.

Surveillance and feedback using NHSN	
1	Conduct monthly surveillance for BSIs and other dialysis events using CDC’s National Healthcare Safety Network (NHSN). Calculate facility rates and compare with rates in other NHSN facilities. Actively share results with frontline clinical staff.
Hand hygiene observations	
2	Perform observations of hand hygiene opportunities monthly and share results with clinical staff.
Catheter/vascular access care observations	
3	Perform observations of vascular access care and catheter accessing quarterly. Assess staff adherence to aseptic technique when connecting and disconnecting catheters and during dressing changes. Share results with clinical staff.
Staff education and competency	
4	Train staff on infection control topics, including access care and aseptic technique. Perform competency evaluation for skills such as catheter care and accessing upon hire and every 6 - 12 months.
Patient education/ engagement	
5	Provide standardized education to all patients on infection prevention topics including vascular access care, hand hygiene, risks related to catheter use, recognizing signs of infection, and instructions for access management when away from the dialysis unit.
Catheter reduction	
6	Incorporate 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.
Chlorhexidine for skin antisepsis	
7	Use an alcohol-based chlorhexidine (>0.5%) solution as the first-line skin antiseptic agent for central line insertion and during dressing changes. ^a
Catheter hub disinfection	
8	Scrub catheter hubs with an appropriate antiseptic after cap removal and before accessing. Perform every time catheter is accessed or disconnected. ^b
Antimicrobial ointment	
9	Apply antibiotic ointment or povidone-iodine ointment to catheter exit sites during dressing change. ^c

^aPovidone-iodine (preferably with alcohol) or 70% alcohol by itself are alternatives for patients with chlorhexidine intolerance. ^bIf closed needleless connector device is used, disinfect connector device as per manufacturer’s instructions. ^cSee information on selecting an antimicrobial ointment for hemodialysis catheter exit sites on CDC website. Use of chlorhexidine-impregnated sponge dressing might be an alternative. Adapted from CDC. CDC Approach to BSI Prevention in Dialysis Facilities (*i.e.*, the Core Interventions for Dialysis Bloodstream Infection (BSI) Prevention [18]).

been demonstrated to be feasible. Dialysis Events that should be reported include: 1) intravenous antimicrobial starts, 2) positive blood cultures, and 3) evidence of local access site infection (pus, redness, or increased swelling at the vascular access site), and data collected from these three events can generate four other types of Dialysis Events: bloodstream infection (BSI), local access site infection (LASI), access-related bloodstream infection (ARB), and vascular access infection (VAI). The number of maintenance HD outpatients who received HD in the unit/center during the first two working days of the month (including transient HD patients but excluding inpatients and peritoneal dialysis patients) should be reported on monthly basis and according to their vascular access type. This will serve as the denominators for rate calculation. Each patient is counted only once; if the patient has multiple vascular accesses, that patient is counted with the vascular access type of highest infection

risk. Rates are calculated by dividing the number of events by the number of patient-months and multiplying the result by 100 [68].

As a means to reduce infection transmission, each dialysis facility should also monitor other parameters like dialysis water and dialysis fluid cultures and endotoxin results, incidence of drug-resistant infections, hospitalizations, as well adherence to *Standard Precautions* (hand hygiene, glove use and other PPE, equipment and environmental cleaning, safe injection practices, etc.), and other recommended practices (screening for HBV, HCV, HIV and tuberculosis infections, and immunizations) [19]. Regular feedback of surveillance results to everyone involved in the healthcare delivery (especially the frontline staff) would help to stimulate and encourage active engagement and improve compliance with infection prevention efforts. At least one designated person with training in infection control and epidemiology (infection preventionist) should be responsible for oversight of the program as well as education of staff and patients related to infection prevention and control [15] [32].

Steps that should be taken to control spread of infection, especially if there is an incidence of a positive seroconversion or outbreak in the HD unit, include the following: 1) revision of the laboratory test results of all patients dialyzing in the same unit to identify any additional case(s), 2) performance of additional testing as indicated in **Table 7**, 3) determination/tracking of potential sources for infection, which includes a) revision of newly infected patients' recent history of blood transfusion, invasive procedure(s) and/or hospitalization, and b) high risk behavior such as history of injection drug use and sexual activity, and 4) revision of HD unit's practices and procedures of infection control [16].

10. Staff and Patient/Family Education

Education and training in infection prevention and control should be provided to all HCWs upon hire and to be repeated regularly (at least once yearly). Basic principles and practices, including hand hygiene and wearing PPE, for preventing the spread of infections should be covered and monitored, and staff competencies should be assessed and documented upon orientation to the facility and to be repeated as appropriate for the specific staff and position [15] [69]. The patient(s) and/or caregiver(s) should also be educated on hand hygiene and the care of new vascular access and whenever there is a change in access type and repeated at least every year [70] [71]. Key areas for patient education as outlined by CDC are shown in **Table 8**.

Table 7. Additional testing to be performed in case of positive seroconversions.

HBsAg Seroconversions [16]	Anti-HCV Seroconversions [72]
<p>In patients newly infected with HBV, HBsAg is the only serologic marker initially detected.</p> <ul style="list-style-type: none"> • 1 - 2 months later: repeat HBsAg testing and test for anti-HBc (including IgM anti-HBc) • 6 months later: repeat HBsAg testing and test for anti-HBs 	<ul style="list-style-type: none"> • If a new HCV infection in a hemodialysis unit is suspected to be nosocomial, testing with NAT should be performed in all patients who may have been exposed. • Repeat testing with NAT is suggested within 2 - 12 weeks in initially NAT-negative patients

Content source: 2001 CDC recommendations for preventing transmission of infections among chronic haemodialysis patients [35], and 2008 KDIGO clinical practice guidelines for the prevention, diagnosis, evaluation and treatment of hepatitis c in chronic kidney disease [72]. HBsAg: Hepatitis B surface Antigen; HCV: Hepatitis C Virus; NAT: Nucleic Acid Amplification.

Table 8. Key areas for patient education.

Patients with Catheters		Patients with Permanent AV Access	
1	Hand hygiene	1	Hand hygiene
2	General access care at home (e.g., bathing with a catheter)	2	Washing the access site prior to treatment
3	Signs and symptoms of infection	3	General access care at home (e.g., don't scratch or pick at the site)
4	How to respond if problems with catheter develop outside of the dialysis center	4	Signs and symptoms of infection
5	Risks associated with catheters/importance of permanent access	5	How to respond if problems with access develop outside of the dialysis center
6	Basic infection control practices during catheter accessing process (as a means to engage patients)	6	Basic infection control practices during cannulation process (as a means to engage patients)

Content source: Centers for Disease Control and Prevention (CDC), National Center for Emerging and Zoonotic Infectious Diseases (NCEZID), Division of Healthcare Quality Promotion (DHQP) [70].

11. Conclusion

Contaminated hands of healthcare workers are among the most common modes of transmission of health-care-associated infections. Hand hygiene is singled out as the most important infection prevention intervention. Compliance can be improved by continuous education, supervision and monitoring of hand hygiene behaviors, providing, in convenient locations, a sufficient number of sinks with soap dispensers, paper towels, hand lotions, and alcohol-based hand rub placed at each patient station. Equally important is the adherence to other *Standard Precautions* including glove and other PPE use, equipment and environmental cleaning, and safe injection practices, as well as other recommended practices of screening for HBV, HCV, HIV, tuberculosis infections, and immunizations. Regular feedback of surveillance results and steps taken to control spread of infection to everyone involved in the healthcare delivery would help to stimulate and encourage active engagement and improve compliance with infection prevention efforts. Education and training and full awareness of infection control policies and procedures should be provided to all HCWs and to be repeated regularly. The patient and/or caregiver should also be educated on hand hygiene and the care of new vascular access. Finally, implementation of evidence-based international guidelines is of great value and instrumental in helping reduce healthcare-associated infections, where patient's safety and well-being remain a top priority.

Conflict of Interest

No conflict of interest.

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Abbreviation Note List

ABHR	Alcohol-Based Hand Rub
ARB	Access-Related Bloodstream Infection
AVF	Arteriovenous Fistula
AVG	Arteriovenous Graft
APIC	Association for Professionals in Infection Control and Epidemiology
BSI	Bloodstream Infection
CDC	Centers for Disease Control and Prevention
C. difficile	Clostridium Difficile
DHQP	Division of Healthcare Quality Promotion
EBPG/ERBP	European Best Practice Guidelines/European Renal Best Practice
HAIs	Healthcare-Associated Infections
HICPAC	Healthcare Infection Control Practices Advisory Committee
HCW	Healthcare Workers
HD	Hemodialysis
HBsAg	Hepatitis B Surface Antigen
HBV	Hepatitis B Virus
HCV	Hepatitis C Virus
HIV	Human Immunodeficiency Virus
KDOQI	Kidney Disease Outcomes Quality Initiative
LASI	Local Access Site Infection
MRSA	Methicillin-Resistant Staphylococcus Aureus
NAT	Nucleic Acid Amplification
NCEZID	National Center for Emerging and Zoonotic Infectious Diseases
NHSN	National Healthcare Safety Network
PPE	Personal Protective Equipment
VA	Vascular Access
VAI	Vascular Access Infection
VRE	Vancomycin-Resistant Enterococci
WHO	World Health Organization



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