Chapter 19
Haemodialysis and Peritoneal Dialysis

Pat Piaskowski

Key points

- Dialysis patients are at high risk of infection because of underlying illness and numerous environmental and procedural factors.
- Establishing a comprehensive infection prevention and control program for dialysis settings will reduce the infection risks for both patients and healthcare providers.
- Patient education is essential to prevent infections associated with dialysis.

Background

Healthy kidneys clean the blood and remove bodily fluids by producing urine. Dialysis can remove metabolic toxins and fluids when the kidneys fail due to disease or damage. Patients who require dialysis have an increased risk of infection due to prolonged vascular access or methods used for dialysis, immunosuppression from end stage renal disease (ESRD), or co-morbid conditions such as diabetes.

There are two types of dialysis: peritoneal dialysis (PD) and haemodialysis (HD). PD involves instillation of dialysis fluids into the peritoneal space via a surgically inserted catheter. HD utilizes a dialysis machine and a dialyser to clean the blood.

Potential adverse events for PD include peritonitis (due to contamination at time of exchange or infection of the exit site), loss of access site, and death.[1-3] For HD, adverse events include bacteraemia, sepsis, and loss of vascular access.[1-2,4] Another contributing factor for infection is failure to use aseptic technique during treatment. Infection prevention and control (IPC) measures (i.e., screening, surveillance, environmental cleaning, aseptic technique, Standard Precautions, and, where necessary, transmission-based precautions) are essential for preventing infections and transmission of microorganisms from patient to patient.

Transmission of infection can take place through contact with blood or body fluids, contaminated equipment, or surfaces. Blood can serve as an environmental source of contamination. Patients who are infected or colonised with microorganisms can also serve as sources for infection transmission. Staff may inadvertently spread infections from patient to patient via direct or indirect contact with contaminated surfaces/equipment or infected/colonised patients. Staff failure to perform hand hygiene, use Standard Precautions or, when required, transmission-based precautions, such as contact or droplet, places patients at risk of infection.

Definitions

Central catheter: Central venous catheters are only intended for short term access use for HD in an emergency, while awaiting a fistula to heal or in preparation for a graft. It carries the highest risk of infection.[5]

Standard central catheter care procedures must be followed to reduce the risk of infection.

Fistula: A connection that is surgically created between an artery and vein (usually in the arm). It is accessed via a needle for HD. It has the lowest risk of infection.[5]

Vascular graft: An artificial tube which is surgically placed between an artery and vein (usually in the arm). This graft is accessed via a needle for HD. It carries an intermediate risk of infection.[5]

Haemodialysis: HD utilises a dialysis machine and a special filter (dialyser) to clean the blood. The patient's blood enters the machine from the access point on the patient (e.g., a fistula, vascular graft, or a temporary central line), is filtered and then returned to the patient. Blood and dialysis fluids do not mix; the blood passes over a semi-permeable membrane which allows some molecules to pass through. This procedure can take up to 3-6 hours and usually takes place three times a week. It is typically carried out in an inpatient or outpatient HD area by trained staff. (See Figure 19.1)

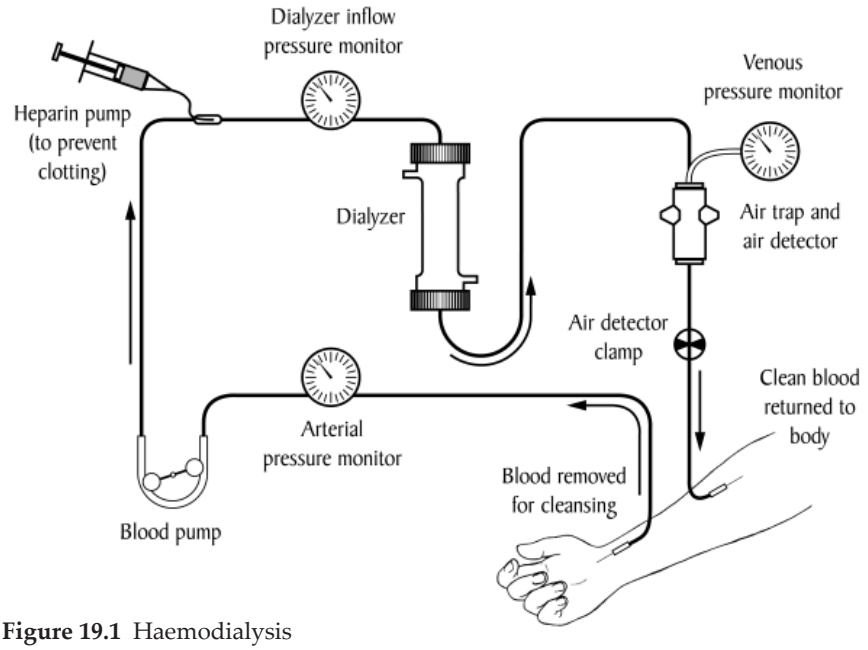

Figure 19.1 Haemodialysis
[Image courtesy of National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health]

Dialysate: A balanced electrolyte solution which is introduced on one side of the semi-permeable dialyser membrane (opposite to the patient's blood) to exchange solutes with blood during haemodialysis.[6]

Dialysis water: Purified water that is used to mix the dialysate or to disinfect, rinse, or reprocess the dialyser.[7]

Dialyser: A part of the HD machine; it has two sections separated by a membrane. The patient's blood flows through one side and the dialysate flows through the other side. (See Figure 19.2)

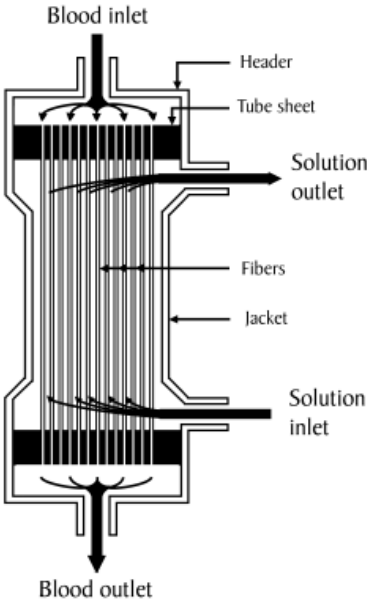

Figure 19.2 Dialyser
[Image courtesy of National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health]

Reverse osmosis (RO): A process used to purify dialysis water by removing dissolved inorganic solutes as well as bacteria and their endotoxins.

Peritoneal dialysis: PD involves dialysis fluid instilled via a surgically inserted PD catheter into the peritoneal space of the abdomen. Most catheters are made from silicone. The fluid is removed, taking with it any toxins. Most common types of PD include chronic ambulatory PD, continuous cyclical PD, and chronic intermittent PD.[6] (See Figure 19.3)

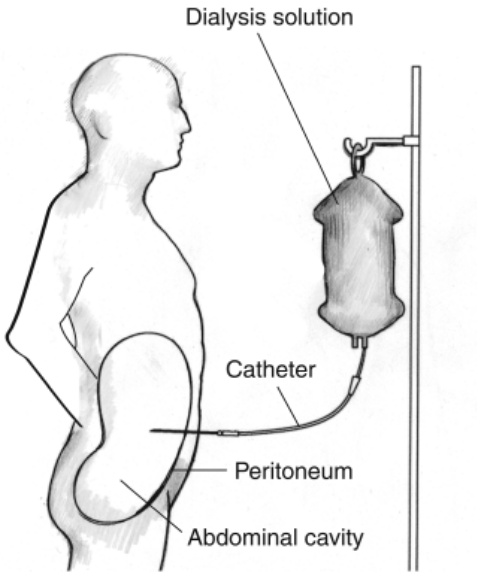

Figure 19.3 Peritoneal Dialysis
[Image courtesy of National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health]

HBsAg: Hepatitis B surface antigen. All patients who are positive for HBsAg are infectious and may transmit Hepatitis B.[5]

Endotoxin concentration: It is measured in endotoxin units per millilitre (EU/ml), while the total viable microbial load is expressed as colony forming units per ml (CFU/ml).

Diagnosis

Diagnosis of infections related to HD or PD includes detection of the following signs and symptoms:

- Systemic infection: Fever, elevated white blood count (WBC), chills or rigors, and\or positive blood cultures.
- Peritonitis: abdominal pain, fever, elevated WBC, chills, or rigors. Culture specimens of exit site drainage and peritoneal fluid should be taken.
- Access site infections: redness or exudate at access site (vascular graft or PD catheter), nausea, vomiting, fatigue, and cloudy effluent.[1] Exudate should be cultured.

Infection-associated Risks

Hepatitis B

Hepatitis B virus (HBV) is transmitted through percutaneous or permucosal exposure to the blood of infected patients (HBsAg-positive or hepatitis B e antigen positive). Blood or body fluids from these positive patients can contaminate the environment which, even when not visibly soiled, can result in transmission of HBV.[5]

HBV remains viable at room temperature for at least seven days;[5] it has been detected on clamps, scissors, and external surfaces and parts of dialysis machines. HBV can be transmitted to patients or staff on gloves or unwashed hands of care providers who touch contaminated surfaces or equipment.[5]

Hepatitis B vaccine for patients is an essential component of IPC measures.[5] Although there is currently a low incidence of HBV infection in many HD patient populations, outbreaks do occur, usually because of failure to use recommended IPC measures.

Hepatitis C

Hepatitis C virus (HCV) is transmitted primarily by percutaneous exposure to infected blood. Factors that increase the likelihood of HCV infection in HD patients include a history of blood transfusions, volume of blood transfused, and years on HD. Like HBV, HCV transmission is often related to inadequate IPC practices.

Outbreaks of HCV have been associated with patients who received their HD treatment immediately after an infected patient. Transmission of HCV has been associated with shared equipment and supplies that were not disinfected between patients, use of common medication carts, shared multi-dose medication vials, contaminated HD machines and related equipment (priming buckets), and blood spills which were not cleaned.[4-5]

Acquired immune deficiency syndrome

Human immunodeficiency virus (HIV) is transmitted by blood or blood-containing body fluids. There have been very few reports of HIV transmission in dialysis and these resulted from inadequate disinfection of equipment, including access needles.[4-5]

Bacterial disease

Dialysis patients are at increased risk of infection and colonisation with multi-drug resistant organisms (MDRO), such as methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE). This is a result of frequent contact with health care facilities, frequent use of antibiotics, and use of invasive devices. VRE infection or colonisation has increased in some HD units. Vancomycin use is high in dialysis populations, contributing to this increase in resistance; this reduces the choice of antibiotics for treating enterococcal infections.[8]

Outbreaks of MRSA have occurred in some dialysis units where colonised \ infected patients served as a source for transmission. In addition there have been reports of vancomycin resistant *S. aureus* (VRSA) among HD patients.[5]

Multidrug-resistant Gram-negative infections in dialysis patients including *Pseudomonas aeruginosa*, *Stenotrophomonas maltophilia*, and *Acinetobacter* spp. have occurred. Some of these infections are resistant to all current antibiotics.[6]

Fungi

Dialysis patients are susceptible to fungal infections caused by microorganisms such as *Aspergillus* spp. Strict adherence to IPC precautions for construction and renovation activities is important. Prompt wiping up of water or other spills prevents mould contamination of the environment with subsequent fungal infections in susceptible populations such as dialysis patients.[1] In addition, there is a risk of Candida bacteraemia and peritonitis with the patient's skin as a source.

Mycobacteria

There have been reports of mycobacterial infections in dialysis patients from contaminated water used for dialysis.[1] Patients with ESRD are at high-risk for progression from latent tuberculosis (TB) infection to active TB disease. The frequent hospitalisation of dialysis patients increases the risk of transmission of TB to other patients or to healthcare providers.

Basic Principles

Surveillance

There are several components to a dialysis surveillance program:

1. Routine testing and documentation of all chronic dialysis patients for HBV and HCV. Routine testing for hepatitis D virus or HIV is not required.
2. Documentation of dialysis patient's vaccination status for vaccine-preventable illnesses.
3. On-going regular and documented surveillance of bacteraemia (microorganisms, treatment, date of onset, precautions used, and date resolved), access site infections, and peritonitis.
4. Records for each patient should include documentation of the location of the treatment station used and machine number, as well as names of staff connecting and disconnecting the patient. This information will be useful in any outbreak investigation.

Infection prevention and control measures

1. **Access site infection prevention and preventing bloodstream infections**
    - Proper hand hygiene must be carried out by all care providers following each of the World Health Organization's 5 moments.[9]
    - Staff must wear a mask and gloves and the patient must wear a mask while the site is being accessed.
    - Locate, inspect, and palpate the access site prior to skin preparation. Repeat skin preparation if the skin is touched by the patient or staff after it has been applied, if cannulation is not completed.
    - Wash the access site using an antibacterial soap/scrub and water. Cleanse the skin by applying 2% chlorhexidine gluconate/70% isopropyl alcohol, 70% alcohol, or 10% povidone iodine as per manufacturer's instructions for use.[2]
    - Access lines used for HD must not be used for other purposes.[8]

2. **Standard and transmission-based precautions**
    - All staff must use Standard Precautions, including hand hygiene, for dialysis patients.

- Staff must follow established procedures for Contact Precautions for antibiotic-resistant microorganisms, such as MRSA and VRE, and relevant antibiotic-resistant Gram-negative microbes.
- Staff should ensure segregation of HBsAg-positive patients and their equipment and supplies from those used for non-HBV-infected patients. Segregation of HBsAg-positive patients and their equipment can result in substantial reduction in the incidence of HBV transmission and infection amongst HD patients.[5]
- Isolation of patients with HCV infection is not recommended.

3. Environmental cleaning and disinfection

- Adequate environmental cleaning with a hospital grade disinfectant is required for all patient areas with special attention to high-touch items or surfaces likely to be contaminated with blood or body fluids.
- There should be procedures to ensure prompt containment and cleaning of spills of blood or body fluids.
- There should also be procedures to ensure prevention of mould contamination resulting from water damage or wetting of permeable walls, furniture, or other items.
- Used supplies and dialysers should be disposed of to prevent contamination of patients and environmental surfaces.

4. Equipment cleaning and disinfection

- Regularly maintained, cleaned, and disinfected dialysis equipment and machines, as well as reusable medical supplies, are essential for reducing the risk of infection.
- There must be policies and procedures for, as well as correct care and maintenance of, dialysis systems, including the water treatment system, distribution system, and dialysis machines.
- Manufacturer recommendations for equipment must be followed.[8]
- Reusable dialysers must be cleaned, receive high-level disinfection, and be thoroughly rinsed and dried prior to reuse. They must be stored to prevent contamination.[7]
- There must be adequate cleaning and disinfection of dialysis machines and equipment and reusable supplies between all patient uses.

5. Safe medication and injection practices

- Avoid contamination of multi-dose vials. The stopper should be disinfected with alcohol before accessing the vial. A single-use sterile needle and syringe should be used for each access. Single-use vials are preferable whenever possible.
- Needles should not be recapped.
- All used sharps should be discarded in designated sharps containers.
- Sharps containers should be available at the point of care to avoid carrying used needles.
- Safety engineered medical devices (e.g., self-retracting or self-sheathing needles) should be used when possible.

6. Patient immunisation, post-vaccination testing, and screening

- Screening programs for HBV and HCV are essential.[5]
- All dialysis patients must be screened for HBV prior to start of HD treatment.[4-5]
- Immunise for HBV. Testing for HBV should take place one to two months after the primary vaccinations. The need for a booster dose of hepatitis B vaccine should be assessed through annual testing for antibody to HBsAg (anti-HBs). A booster dose should be administered when anti-HBs levels decline to <10 mIU/ml.
- Patients should be screened for HCV prior to receiving HD[4-5] and at 6-month intervals.
- Dialysis patients younger than 65 years of age should receive a dose of pneumococcal vaccine followed by a dose every 5 years. If over 65 years, only one dose of vaccine is required.
- Screening of patients for MRSA or VRE is only necessary when there is an outbreak or suspected transmission in the dialysis unit.

7. Patient and healthcare provider education

- The staff should receive initial and on-going education on the basic principles and practices of dialysis, infectious risks and potential adverse events, and IPC practices.
- The patient should receive education on access site and dressing care, signs and symptoms of infection, and the importance of reporting potential infections.

8. **Occupational safety considerations**
    - Staff who care for dialysis patients must follow Standard Precautions and, as necessary, transmission-based precautions, including use of appropriate personal protective equipment and hand hygiene to protect themselves from contact with and potential infection from blood or body fluids.
    - Gloves, masks, and gowns must be used when connecting and disconnecting dialysis patients during the dialysis process.
    - Routine testing of staff for HCV, HBV, or MDRO is not recommended.
    - Staff should receive hepatitis B vaccination.

9. **Water treatment and testing**
    - Testing of dialysis water and dialysate should be performed at least monthly per the US Association for the Advancement of Medical Instrumentation (AAMI) guidelines.[7]
    - Water used to prepare dialysate or to process dialysers and dialysate should contain a total viable microbial count of no more than 200 CFU/ml and an endotoxin concentration lower than 2 EU/ml. If the total viable microbial count reaches 50 CFU/ml or the endotoxin concentration reaches 1 EU/ml, corrective measures should be taken promptly.[7]
    - There should also be procedures and policies for testing and for follow-up when results are not within acceptable limits.

Low Resource Issues

In areas where access to resources is limited, the main IPC priorities are:

1. Safe reprocessing and reuse of dialysers.
2. Use, maintenance, and testing of safe, reliable water supply for dialysis.[10]
3. Spatial separation or segregation of patients infected with HBV or infected or colonised with MDRO, such as MRSA and VRE. Supplies should also be kept separate.
4. Access to reliable methods for regular cleaning and disinfection of surfaces and equipment in the dialysis area.
5. Access to lab testing for HBV/HCV status of patients and detection of other infections related to dialysis.
6. Access to HBV vaccine for patients and staff.

Relevant Guidelines

- Kidney Disease Outcomes Quality Initiative (KDOQI) http://www.kidney.org/professionals/KDOQI/guidelines.cfm [Accessed July 26, 2011]
- International Society for Peritoneal Dialysis (ISPD) Guidelines/Recommendations http://www.ispd.org/lang-en/treatmentguidelines/guidelines [Accessed July 26, 2011]

Summary

Dialysis (HD or PD) is a lifeline for patients with ESRD or renal failure and \ or awaiting kidney transplant. Patients receiving dialysis treatments are at increased risk of infection. The risk of infection or other adverse events can be reduced by prevention and control measures. Implementation of IPC procedures and a safe environment, including safe water, are all critical in eliminating or mitigating infection risk for this group of patients. The patient also has an important part to play in preventing infection and requires appropriate education.

References

1. Ronco C, Aquila R, Rodighiero MP (eds): Peritoneal Dialysis: A Clinical Update. *Contrib Nephrol Basel* 2006; 150: 181-186.
2. National Kidney and Urologic Diseases Information Clearinghouse. National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). http://kidney.niddk.nih.gov/ [Accessed July 25, 2011]
3. Piraino B, Bailie GR, Bernadini J, et al. ISPD guidelines/recommendations: Peritoneal dialysis-related infections recommendations: 2005 update. *Perit Dialysis Int* 2005; 25: 107-331.
4. Alter M, et al. Nosocomial infections associated with hemodialysis. In: CG Mayhall (ed), *Hospital Epidemiology and Infection Control*, 3rd edition, Lippincott Williams and Wilkins, Baltimore, MD, 2004; 1139-60.
5. CDC Recommendations for Preventing Transmission of Infections among Chronic Hemodialysis Patients. *MMWR* 2001; 50(RR05):1-43. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5005a1.htm [Accessed July 25, 2011]

6. Garcia-Houchins S, Dialysis. In: *APIC Text of Infection Control and Epidemiology*. Association for Professionals in Infection Control and Epidemiology, Inc., Washington, DC. 2009; 48-1-48.17.
7. AAMI Standards and Recommended Practices for Dialysis. Arlington VA. Association for the Advancement of Medical Instrumentation, 2010.
8. Friedman C, Petersen K. Infection control in ambulatory care. Jones and Bartlett, Sudbury, Massachusetts; 2004; 97-108.
9. World Health Organization Guidelines on Hand Hygiene in Health Care, 2009. http://apps.who.int/medicinedocs/documents/s16320e/s16320e.pdf [Accessed July 5, 2011]
10. Vivekanand J, Chugh K. The practice of dialysis in developing countries. Hemodial Int 2003; 73:239-249.