Infection prevention in home dialysis

Muthana Al Sahlawi[a], *Christopher T. Chan*[b,c] *and Jeffrey Perl*[d]

Purpose of review
Among patients with kidney failure, home dialysis modalities, including peritoneal dialysis (PD) and home hemodialysis (HHD) provide several individual and healthcare system benefits over in-center hemodialysis (HD). Infection remains a major source of morbidity and mortality in this population, and a core outcome of critical importance to patients, caregivers, and kidney health professionals. This narrative review provides evidence-based measures for infection prevention among individuals receiving home dialysis, with a particular emphasis on dialysis and access-related infections.

Recent findings
Patient and care partner education and training is an important and major theme for infection prevention in home dialysis. In PD, identifying and managing modifiable risk factors for infections such as hypokalemia, constipation, use of gastric acid suppressants, and domestic pets, along with the use of antimicrobial prophylaxis, when indicated, can substantially reduce peritonitis risk. Reducing the use of central venous catheters (CVC), and duration of CVC dependence is the most effective means of prevention of HD access-related bloodstream infections in individuals receiving HHD. For arteriovenous fistula cannulation, rope ladder technique is associated with lower risk of infection compared to buttonhole cannulation.

Summary
Developing and instituting a well structured and evidence-based patient training and education program within home dialysis units is the most important measure in preventing and reducing dialysis and access-related infections. Kidney care providers should be familiar with different infection risk factors among individuals receiving home dialysis.

Keywords
home dialysis, home hemodialysis, infection, infection prevention, peritoneal dialysis

INTRODUCTION

Home over center-based dialysis modalities, including peritoneal dialysis (PD) and home hemodialysis (HHD), offer several benefits to individuals with kidney failure, particularly with respect to improvements in quality of life and patient autonomy [1–4]. In addition, in many countries, these modalities are more cost effective than in-center hemodialysis (ICHD) [5,6]. However, infections remain a leading cause of morbidity and mortality in individuals receiving home dialysis. Previous studies have reported that dialysis patients have an up to 100-fold increase in age-adjusted risk of death from infection, as compared to general population [7]. This highlights the critical importance of infection prevention and early identification and treatment of infection to reduce infection-related morbidity and mortality in this group of patients.

Peritoneal dialysis associated peritonitis is a major source of hospitalization events, added treatment costs, and is the primary cause of premature transition to ICHD [8,9]. As a result, PD-related infection has been identified as a core outcome of critical importance to patients, caregivers, and kidney health professionals in the multistakeholder SONG (Standardized Outcomes in Nephrology) PD initiative [10]. In individuals treated with HHD, infections are a leading cause of hospitalizations, responsible for as high as 36% of all HHD-related hospitalizations [11].

Home dialysis-related infections are often due to the dialysis access, including the arteriovenous (AV) access or central venous catheter (CVC) for HHD, or

[a]Department of Internal Medicine, College of Medicine, King Faisal University, Al-Hasa, Saudi Arabia, [b]Division of Nephrology, University Health Network, Toronto, [c]Toronto General Hospital Research Institute, University Health Network and [d]Division of Nephrology, St. Michael's Hospital, University of Toronto, Ontario, Canada

Correspondence to Dr Jeffrey Perl, Division of Nephrology, St. Michael's Hospital, 61 Queen St. East 9-128, Toronto, Ontario M5C 2T2, Canada. Tel: +1 416 864 6016; fax: +1 416 488 1048; e-mail: jeff.perl@utoronto.ca

Curr Opin Nephrol Hypertens 2025, 34:95–103
DOI:10.1097/MNH.0000000000001032

KEY POINTS

- Dialysis and access-related infections are a leading cause of morbidity and mortality in individuals receiving home dialysis.
- Patient education, training, and retraining are all essential key components in preventing and reducing infection rates in home dialysis patients.
- Antibiotic prophylaxis, when indicated is an important strategy to reduce peritonitis risks following certain events/procedures.
- In peritoneal dialysis, hypokalemia, constipation, use of gastric acid suppressants, and domestic pets are modifiable risk factors for peritonitis.
- In home hemodialysis, rates of catheter-related blood stream infections can be significantly reduced by reducing the use of hemodialysis catheters, and duration of catheter dependence. For arteriovenous fistulas, rope ladder cannulation is associated with lower risk of infection compared to buttonhole technique.

the PD catheter. Of note, peritonitis may or may not be access-related. Preventing and reducing dialysis and access-related infections in home dialysis starts by developing and instituting a robust patient training and education program, focusing on different infection prevention measures, including access care, hand hygiene, and early recognition of infection. Such a program should include a motivated and multidisciplinary stakeholder team comprising nephrologists, nurses, social workers, pharmacists, microbiologists, technicians, and access operators, along with the engagement of patients and patients' care partners.

This review provides evidence-based measures for infection prevention in home dialysis patients, focusing on the prevention of home dialysis-related infections with a particular emphasis on access-related and exit-site infections (Fig. 1).

THE ROLE OF PATIENT TRAINING AND EDUCATION ON INFECTION PREVENTION IN HOME DIALYSIS

Successful patient training is a key component in preventing infections in home dialysis. Ensuring high-quality training on optimal and aseptic PD and HHD technique for patients and care partners is a crucial strategy to reduce infection rates in home dialysis. Such a strategy must consider the interplay between what content to present including didactic and skills-based content, optimal methods of delivery, how to evaluate successful learning and implementation, and assess

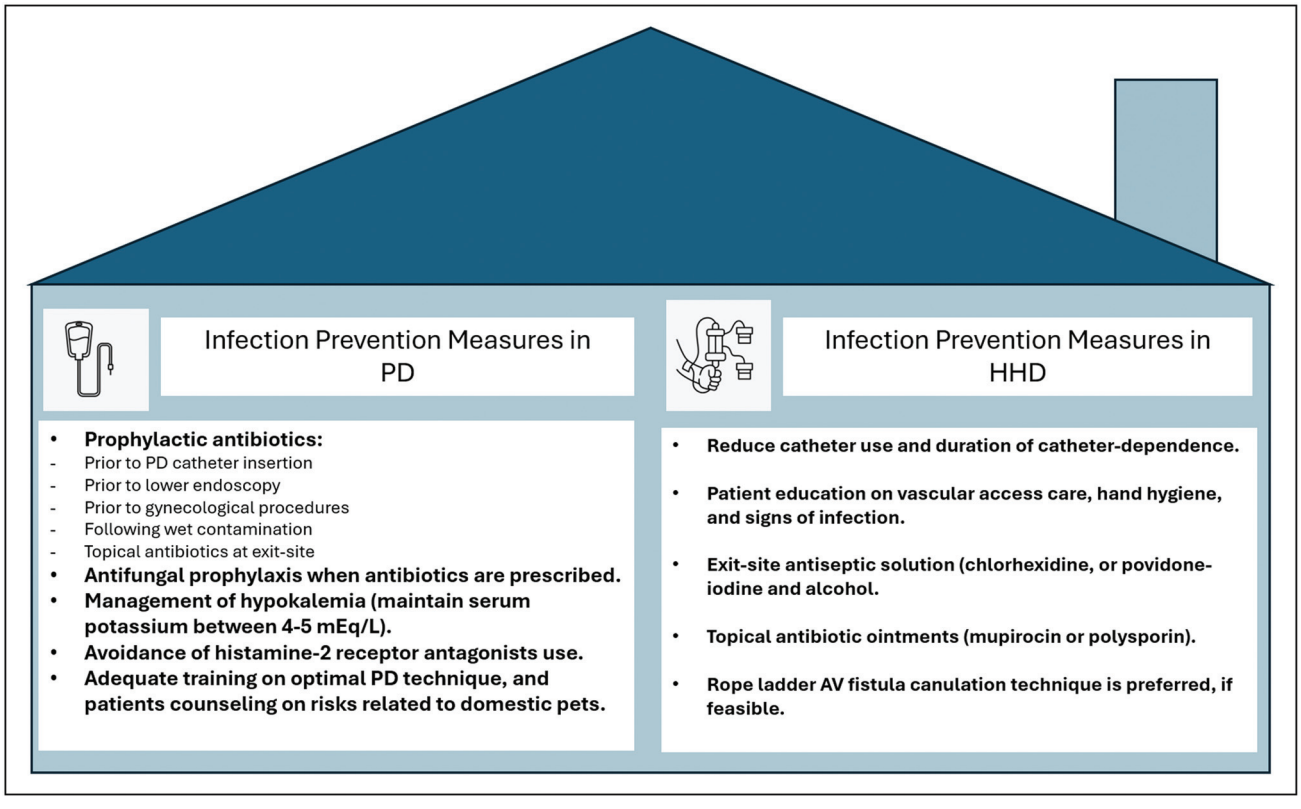

FIGURE 1. Infection prevention measures in home dialysis.

ongoing competency. Previous studies have shown that poor adherence to an aseptic PD exchange and HHD technique are associated with a higher risk of infections [12–14]. The International Society for Peritoneal (ISPD) recommends that each PD program should have a well structured training syllabus that is followed in teaching the patient the procedure, and assessing patient's skills and technique [15]. Such training on PD technique should begin in preparation for PD, continue at PD initiation and be assessed and reinforced on a regular basis, particularly following a sentinel event. Such events may include: an infection episode, prolonged hospitalization, a period of PD therapy interruption, or changes in environment, care partner, PD equipment or connectology.

Of note, The Targeted Education ApproaCH to improve Peritoneal Dialysis outcomes (TEACH-PD) is large ongoing open-label, multicenter, binational, cluster-randomized controlled trial, aiming to provide high-certainty evidence on the impact of a standardized and structured PD training curriculum for PD nurse trainers and patients in reducing PD-related infections. The primary study outcome of TEACH-PD is the time to the first occurrence of any PD-related infection [16▪▪].

Individuals trained for HHD often require a longer duration of training (8–12 weeks) compared to PD. Education on different infection prevention measures, including access care, aseptic protocols, and early recognition of signs of infection constitute a major part of such training. Of note, a recent study examined the impact of different patients' learning styles (visual, aural, reading-writing, and kinesthetic) on the risk of adverse events in newly trained home dialysis patients. The study demonstrated that visual learning was shown to be associated with lower adverse events, including infections within the first 6 months of training completion [17]. Training should often be individualized and may require an adaptive approach considering tailored teaching approaches for various learning styles. Lastly, having a well structured home visit program, including home visit audits for home dialysis patients could provide additional support for patients and identify and mitigate different infection risks related to the treatment environment or technique [18,19].

INFECTION PREVENTION MEASURES IN PERITONEAL DIALYSIS

Infection prevention at the time of PD access placement

Prior to initiation of PD treatment, and at the time of PD catheter insertion, the rate of early catheter-related Gram-positive peritonitis can be substantially reduced by the administration of perioperative systemic antibiotics, supported by a systematic review of four randomized, controlled trials (RCTs) [15,20]. The choice of these systemic antibiotics includes either a first-generation cephalosporin or vancomycin, which should be selected based on local microbiology patterns of antimicrobial resistance. In terms of PD catheter type, although previous studies have found similar risk of catheter-related infection with use of straight versus coiled tip catheters, the use of double cuff PD catheter has been demonstrated to reduce peritonitis risk, particularly *Staphylococcus aureus* peritonitis in a large pan-Canadian retrospective observational study involving 4247 PD incident PD patients [21]. Although note widely popular, PD catheter embedment technique is used in some centers. Embedded catheters were initially designed to heal in a sterile environment with the assumption that they would be associated with a reduction in biofilm formation and risk of infection. However, studies have suggested that infection risk is not significantly different between embedded and nonembedded catheters. Exit-site infections may be higher owing to the fact the exit site will require to be externalized, yet further studies are required [22].

With regards to different PD catheter placement techniques, risk of early infection was shown to be higher in a recent multicenter study for the United Kingdom with the use of surgical technique, compared to medical (percutaneous) insertion [23▪]. Moreover, in a recent systematic review that included both RCTs and observational studies, the risk of exit-site infections was shown to be lower (with low certainty evidence) with the use of percutaneous PD catheter insertion compared to surgical (open or laparoscopic) technique [24]. However, the studies from this systematic review were confounded, and the surgical group included the open approach, which is becoming less of a standard of care compared to use of an advanced laparoscopic technique. Given such uncertainty, and as suggested by the ISPD, the choice of PD catheter type and placement technique should be left to shared decision-making between the individual clinician and patient and may often be dictated by local resources [25].

Of note, the location of the exit site should be carefully chosen prior to catheter insertion with the patient in multiple (included the seated) position. The exit site's location should allow the patient to be able to see and clean the exit site, and to avoid potential trauma to the catheter. In certain circumstances, such as morbid obesity, or intestinal stomas, alternative, distant PD catheter exit-site locations,

such as upper abdominal or presternal should be considered [26]. Yet, extended catheters with remote exit-site locations were shown to be associated with higher rates of catheter loss and should be only attempted when conventional lower abdominal sites are not feasible [27].

In all cases, sutures should be avoided at the PD catheter exit site to minimize risks of infection [26]. Following the insertion of the PD catheter, the exit site should be covered and dressing to be left intact for 7 days unless soiled in order to immobilize the catheter, promote healing, and reduce infection risks.

The role of antimicrobial prophylaxis

Antibiotic prophylaxis in is an important strategy to reduce peritonitis risks following certain procedures. In addition to the role of systemic antibiotics prior to PD catheter insertion (discussed earlier), prophylactic antibiotics are also recommended prior to lower endoscopy and prior to gynecological procedures, given the increased risk of peritonitis followings these procedures [15]. Of note, PD fluid should be drained prior to colonoscopy and gynecological procedures to keep the abdomen empty. There is insufficient evidence regarding the role of prophylactic antibiotics prior to upper endoscopy. Such decision should be individualized (patient's age and number of endoscopic biopsies may be predictive of peritonitis risk) [28]. Despite reported cases of peritonitis, particularly streptococcal viridans peritonitis following dental procedures, antibiotic prophylaxis may not be practical approach given that toothbrushing was shown in some studies to have greater risk of developing bacteremia than tooth extraction [29]. As a result, antibiotic prophylaxis prior to dental procedures is no longer recommended in the most recent ISPD guidelines [15]. The type of the procedure/event and prophylactic systemic antibiotic choices are summarized in Table 1.

Another important infection prevention measure is the administration of prophylactic antibiotics following a wet contamination of the PD system. A wet contamination refers to any external exposure of PD fluid during the PD procedure outside of what should be a completely closed system. This includes leaking from dialysate bags, leaks in the tubing, the PD catheter, or transfer set, and/or breach of aseptic technique during the exchanges being performed. In a single-center study of 548 episodes of touch contamination in Hong Kong among which 302 were wet contamination events, peritonitis occurred in 5.6% of these episodes [30]. Patients should be instructed to seek advice immediately from their PD unit if the sterility of the PD exchange has been compromised. In this case, administration of a single dose of intraperitoneal (IP) cefazolin to cover Gram-positive organisms should be considered [15]. However, for patient convenience, and to balance the risk of not reporting such incidence by patients, it is reasonable alternative to provide patients with oral antibiotics for self-administration at home when wet contamination is suspected as a clear and direct consequence of breach in technique with no suspicion of an ongoing source from PD catheter or transfer set injury.

Fungal peritonitis carries the highest risk of hospitalization, PD catheter removal, hemodialysis transfer, and mortality [8]. Prior antibiotic treatment

Table 1. The type of procedure/event and prophylactic systemic antimicrobial choice in PD patients

Procedure/events	Choice of prophylactic antionbioc
PD catheter insertion	Intravenous first-generation cephalosporin or vancomycin immediately prior to catheter placement
Lower endoscopy	Intravenous cephalosporins (ceftriaxone or ceftazidime), amoxicillin–clavulanate, ampicillin–sulbactam, ampicillin plus aminoglycoside Alternative oral antibiotic prophylaxis option may include ampicillin 1000 mg, ciprofloxacin 500 mg and/or metronidazole 250 mg 1 to 2 h before colonoscopy
Gynecological procedures	Intravenous cefazolin or ceftriaxone before the procedure or oral cefadroxil 500 mg once daily for 3 days
Upper endoscopy	No standardized recommendation
Dental procedures	No longer recommended
Wet contamination	Single dose of intraperitoneal cefazolin
Systemic antibiotics (for peritonitis or any other indication)	oral nystatin 500 000 units, 4 times per day for the entire duration of antibiotic therapy plus 1 week following antibiotic discontinuation. Alternative option may include oral fluconazole (200 mg every 48 h)

PD, peritoneal dialysis.

for peritonitis (or any other indication) is an important risk factor for fungal peritonitis, as antibiotic use can disrupt the normal bowel flora, promoting enteric fungal overgrowth [31,32]. As a result, antifungal prophylaxis in patients receiving antibiotics is an important measure to prevent fungal peritonitis and is part of the ISPD peritonitis prevention guidelines (evidence level 1B), supported by two RCTs and a systematic review [15,33–35]. Generally, oral nystatin (500 000 units, 4 times per day for the entire duration of antibiotic therapy plus 1 week following antibiotic discontinuation) is the preferred agent given the low cost, safety profile, and its strong evidence base in preventing antibiotic-associated fungal peritonitis [33,36]. However, in immunocompromised patients and those on multiple broad-spectrum antibiotics, escalation to fluconazole or other antifungals can be considered [34]. Yet, the benefit of using fluconazole should be balanced against the potential risk of systemic adverse effects, drug interactions, and the development of resistant strains. It should be noted that consideration for fungal prophylaxis needs to be taken in the context of baseline rates of fungal peritonitis.

Avoiding hypokalemia

Persistent hypokalemia has been recently shown to be an important modifiable risk factor for PD peritonitis. Data from the international Peritoneal Dialysis Outcomes and Practice Patterns Study (PDOPPS) has demonstrated that persistent hypokalemia for 4 months is associated with 80% higher subsequent peritonitis rates [37]. This was consistent with another propensity-matched score study from Brazil, demonstrating higher infection-related mortality and peritonitis risk in PD patients with hypokalemia [38]. Dietary intervention and potassium replacement are therefore warranted to mitigate such risks. Moreover, in a recent multicenter randomized controlled trial, the efficacy of potassium supplementation in individuals receiving PD was examined. Among 167 patients with time-averaged serum potassium concentrations of 3.33 $\pm$0.28 mEq/l, 85 were assigned to receive protocol-based treatment (titratable dose of oral potassium chloride to maintain serum potassium of 4–5 mEq/l), and 82 patients to receive conventional (reactive) supplementation when the serum potassium fell below 3.5 mEq/l. Over a median follow-up time of 401 (interquartile range, IQR, 315–417) days, the protocol-based group had a significantly lower hazard of peritonitis (hazard ratio, HR, 0.47 [95% confidence interval (CI), 0.24–0.93]), and a longer median time to first peritonitis episode compared to the reactive treatment group (223 [IQR, 147–247] versus 133 [IQR, 41–197] days, $P = 0.03$) [39].

Bowel hygiene and the use of gastric acid suppressants

Factors such as constipation, and the use of gastric acid suppression have been shown to increase the risk of enteric peritonitis [40,41]. In a recent study from the PDOPPS, the risk of enteric peritonitis was shown to be higher among gastric acid suppressants users [42▪]. Of note, the latest ISPD guidelines suggest to avoid the use of histamine-2 receptor antagonists in PD patients [15]. In addition to the role of laxatives in maintaining the efficacy of PD treatment and preventing flow dysfunction, observational data have suggested that the regular use of lactulose was associated with lower rates of peritonitis, highlighting the need of having bowel routine protocols in place [43].

Domestic pets

Patients should be asked if domestic pets are kept at home, as this can increase the risk of peritonitis. Cases of peritonitis due to certain organisms, such as *Pasteurella multocida*, which is known to colonize the upper respiratory tract in most cats and dogs are well reported [44–48]. In a recent study from the PDOPPS, patients who owned both cats and dogs were shown to have an increased risk of peritonitis compared to patients with cats only, or those without pets [49▪]. in a study from the French Language Peritoneal Dialysis Registry (RDPLF), the outcomes of patients who experienced cat-related peritonitis ($n = 52$) were compared with a group of 208 matched patients who experienced peritonitis due to other causes. There was no significant difference between the two group in terms of mortality and HD transfer rates [50▪]. Given that automated PD (APD) requires more equipment (tubing, cycler) than continuous ambulatory peritoneal dialysis (CAPD), it could be hypothesized that patients on APD might be at particular higher risk of cat-related peritonitis than those using CAPD. Taking together, owning pets should not be a contraindication to PD, but patients should be educated about the importance of adhering to a strict hand hygiene after handling pets. Ideally, domestic pets should not be allowed in the room when PD exchanges are performed, and where the PD machine, solutions, and equipment are stored.

INFECTION PREVENTION MEASURES IN HOME HEMODIALYSIS

Access type and risk of infection risks

Bloodstream infections remain a major source of morbidity and mortality in the HD population, with most of these infections being related to the vascular

access, particularly the use of a CVC. As a result, reducing catheter-related blood stream infections (CRBSI) in HD patients has been identified as a national priority by the US department of health and human services, leading the Centers for Medicare and Medicaid Services (CMS) to incorporate reporting of bloodstream infections to the National Healthcare Safety Network (NHSN) by all HD facilities in the states. Future mandating of such reporting for those receiving HHD should be considered.

Among ICHD patients, the incidence of bacteremia and the risk of infection-related hospitalization and mortality are substantially higher in patients using tunneled catheters, as compared to those who have either AV fistulas or grafts [51–53]. In HHD patients, although infection risks were not examined, CVC-use was also associated with higher risk of death and transfer off home dialysis, compared to AV fistula use in a large Canadian registry-based study [54].

The most effective means of prevention of CRBSIs is reducing the use of catheters, and the duration of catheter dependence. Of note, the fear of self-cannulation and needle dislodgment were identified as a major HHD patient-perceived barrier to the use of AV access [55]. Addressing this barrier by standardized education and training might help in reducing rates and duration of catheter use in HHD patients. General CRBSI prophylactic measures should be followed similar to those as endorsed in conventional HD patients. This includes adequate education on vascular access care, hand hygiene, risks related to catheter use, and recognition of signs of infection. Although previous meta-analyses have demonstrated a significant reduction in CRBSI with the use of prophylactic antimicrobial locking solutions, this practice has not been widely adopted [56]. This is related to concerns regarding the potential development of antimicrobial resistance with the prolong use of antimicrobial locking solutions.

Method of arteriovenous fistula cannulation

Although AV fistulas are associated with lower infectious complications compared to CVCs, the risk of infection may vary depending on the choice of fistula cannulation technique. Rotating needle placement sites (rope ladder technique) is the most frequently used cannulation method in dialysis facilities, and is the recommended cannulation technique for AV fistulas by the kidney disease outcomes quality initiative (KDOQI) guidelines [57]. Although a constant site technique using blunt needle, commonly known as the buttonhole technique was preferred by some HHD patients because of ease of cannulation and reduced pain, there is now a trend to move away from this technique, given the higher rates of infectious events with buttonhole compared with rope ladder cannulation [58–60]. In an Australian retrospective study that included 90 consecutive HHD patients, the use of buttonhole cannulation was associated with a significantly higher rate of AVF infections (incidence rate ratio, 3.85; 95% confidence interval, 1.66 to 12.77; $P = 0.03$), as compared with rope ladder technique [61]. This was consistent with a systematic review of 15 studies in HD patients showing approximately threefold higher infection risk with buttonhole cannulation compared with the rope-ladder technique [61]. However, buttonhole cannulation may be considered in certain circumstances, particularly in patients who have limited area for needle cannulation and with education on optimal aseptic technique. This includes the use of separate blunt needle for each buttonhole site, ensuring the scab in completely removed, cleaning the cannulation area with antiseptic solutions, and applying antimicrobial ointment following needle removal.

EXIT-SITE CARE OF PERITONEAL DIALYSIS AND CENTRAL VENOUS CATHETERS

Infection at the PD catheter exit-site, defined as the presence of purulent discharge, with or without erythema of the skin is a major concern in patients receiving PD given the increased risk of subsequent tunnel infection, peritonitis, and catheter loss [62,63]. Exit-site infections (ESI) are often caused by organisms such as coagulase-negative *Staphylococcal* species, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* [64]. In addition to the role of patient training and education, having PD catheter exit-site care protocol in place is a necessary measure to reduce ESI rates. Generally, exit-site should be cleansed at least twice weekly, and after shower using either antibacterial soap, nonantibacterial soap, chlorhexidine, povidone-iodine, or sodium hypochlorite [65]. Of note, no cleansing agent has been shown to be superior to another for the prevention of ESI [25]. Additionally, the daily topical application of antibiotic ointment or cream, including either mupirocin or gentamicin to the catheter exit site is recommended to prevent catheter-related infection [25]. In a meta-analysis examining the benefit of mupirocin prophylaxis, the risk of *Staphylococcus aureus* ESI was reduced by 62% among those using mupirocin [66]. In general, the use of local antibiotic cream/ointment should be accompanied by surveillance for antimicrobial resistance. Although gentamicin has been shown to be as effective as mupirocin in reducing *Staphylococcus aureus* ESI, and an effective

prophylactic agent for *Pseudomonas* species, there are ongoing concerns regarding gentamicin resistance, and the possibility of the development of certain atypical organisms [67–69].

For HHD, patients should be instructed to change catheter dressing with each HD treatment, with chlorhexidine being the preferred exit-site antiseptic solution [70,71]. if chlorhexidine cannot be used (e.g., sensitivity, allergy), povidone-iodine and alcohol remain effective alternatives [72]. in terms of exit-site dressing type, either sterile gauze or transparent, semipermeable dressing can be used, given the comparable outcomes of both dressings in respect of exit-site colonization and CRBSIs risks [73]. Although the routine application of topical antibiotic ointments, including mupirocin or polysporin triple antibiotic ointment at the catheter exit-site can significantly reduce the risk of CRBSIs, this practice should be based on local infection rates, given the concerns of emergence of resistant strains, particularly with use of mupirocin [74,75].

CONCLUSION

Infections in home dialysis patients are associated with significant morbidity, mortality, added treatment costs, and hospitalization events. Having a well structured and evidence-based patient training and education program is an important key component in preventing and reducing infection rates in home dialysis. Antibiotic prophylaxis, when indicated, can substantially reduce peritonitis risk and dialysis access-related infections in home dialysis patients. Of note, ongoing infection prevention efforts in patients receiving home dialysis should also be accompanied by antimicrobial stewardship given the growing evidence to support the role of antimicrobial stewardship programs in reducing infection-related adverse events, treatment costs, and antimicrobial resistance rates. In this regard, the Centers for Disease Control and Prevention (CDC) core elements of antimicrobial stewardship may provide a set of key principles to improve antibiotic use and advance patients' safety and improve outcomes [76]. However, an important gap that was identified while conducting this review is the absence of clear evidence for antimicrobial stewardship in home dialysis. Given the heavy use of therapeutic and prophylactic antibiotics in patients on home dialysis, considerations should be given for future and analogous antimicrobial stewardship efforts in home dialysis.

Acknowledgements

None.

Financial support and sponsorship

None.

Disclosures: M.A.S. has received speaker fees from Baxter, FMC, GSK, AstraZeneca, Vifor pharma, and Boehringer Ingelheim. C.T.C. holds the R Fraser Elliott Chair in Nephrology. He also has an investigator-initiated grant from Medtronic and Red Sense. J.P. declares employment/consultancy with Baxter, GSK, Otsuka, AstraZeneca, Amgen, Bayer, and Davita and has received speaker fees from Baxter, Davita, FMC, ARA, and US Renal Care, as well as stock/stock options in i-ren.

Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- ■ of special interest
- ■■ of outstanding interest

1. Dahlerus C, Quinn M, Messersmith E, *et al.* Patient perspectives on the choice of dialysis modality: results from the empowering patients on choices for renal replacement therapy (EPOCH-RRT) study. Am J Kidney Dis 2016; 68:901–910.
2. Walker RC, Hanson CS, Palmer SC, *et al.* Patient and caregiver perspectives on home hemodialysis: a systematic review. Am J Kidney Dis 2015; 65:451–463.
3. Rubin HR, Fink NE, Plantinga LC, *et al.* Patient ratings of dialysis care with peritoneal dialysis vs hemodialysis. JAMA 2004; 291:697–703.
4. Chaudhary K, Sangha H, Khanna R. Peritoneal dialysis first: rationale. Clin J Am Soc Nephrol 2011; 6:447–456.
5. McFarlane PA, Pierratos A, Redelmeier DA. Cost savings of home nocturnal versus conventional in-center hemodialysis. Kidney Int 2002; 62:2216–2222.
6. Karopadi AN, Mason G, Rettore E, Ronco C. Cost of peritoneal dialysis and haemodialysis across the world. Nephrol Dial Transplant 2013; 28:2553–2569.
7. Sarnak MJ, Jaber BL. Mortality caused by sepsis in patients with end-stage renal disease compared with the general population. Kidney Int 2000; 58:1758–1764.
8. Al Sahlawi M, Zhao J, McCullough K, *et al.* Variation in peritoneal dialysis-related peritonitis outcomes in the peritoneal dialysis outcomes and practice patterns study (PDOPPS). Am J Kidney Dis 2022; 79:45.e1–55.e1.
9. Mehrotra R, Devuyst O, Davies SJ, Johnson DW. The current state of peritoneal dialysis. J Am Soc Nephrol 2016; 27:3238–3252.
10. Manera KE, Johnson DW, Craig JC, *et al.* Patient and caregiver priorities for outcomes in peritoneal dialysis: multinational nominal group technique study. Clin J Am Soc Nephrol 2019; 14:74–83.
11. Bi SH, Tang W, Rigodanzo-Massey N, *et al.* Infection-related hospitalizations in home hemodialysis patients. Blood Purif 2015; 40:187–193.
12. Dhruve M, Faratro R, D'Gama C, *et al.* The use of nurse-administered vascular access audit in home hemodialysis patients: a quality initiative. Hemodial Int 2019; 23:133–138.
13. Rousseau-Gagnon M, Faratro R, D'Gama C, *et al.* The use of vascular access audit and infections in home hemodialysis. Hemodial Int 2016; 20:298–305.
14. Russo R, Manili L, Tiraboschi G, *et al.* Patient re-training in peritoneal dialysis: why and when it is needed. Kidney Int Suppl. 2006:S127–32.
15. Li PK, Chow KM, Cho Y, *et al.* ISPD peritonitis guideline recommendations: 2022 update on prevention and treatment. Perit Dial Int 2022; 42:110–153.
16. ■■ Chow JSF, Boudville N, Cho Y, *et al.* Multicenter, pragmatic, cluster-randomized, controlled trial of standardized peritoneal dialysis (PD) training versus usual care on PD-related infections (the TEACH-PD trial): trial protocol. Trials 2023; 24:730.

This ongoing trial is investigating the impact of a standardized and structured PD training curriculum for PD nurse trainers and patients in reducing PD-related infections.

17. Auguste BL, Girsberger M, Kennedy C, *et al.* Are adverse events in newly trained home dialysis patients related to learning styles? A single-centre retrospective study from Toronto, Canada. BMJ Open 2020; 10:e033315.
18. François K, Faratro R, d'Gama C, *et al.* Utility of baseline home visit audit in home hemodialysis. ASAIO J 2015; 61:695–700.

19. Martino F, Adıbelli Z, Mason G, *et al.* Home visit program improves technique survival in peritoneal dialysis. Blood Purif 2014; 37:286–290.
20. Gadallah MF, Ramdeen G, Mignone J, *et al.* Role of preoperative antibiotic prophylaxis in preventing postoperative peritonitis in newly placed peritoneal dialysis catheters. Am J Kidney Dis 2000; 36:1014–1019.
21. Nessim SJ, Bargman JM, Jassal SV. Relationship between double-cuff versus single-cuff peritoneal dialysis catheters and risk of peritonitis. Nephrol Dial Transplant 2010; 25:2310–2314.
22. Keskar V, Biyani M, Blew B, *et al.* Characteristics and outcomes of exit sites of buried peritoneal dialysis catheters: a cohort study. Perit Dial Int 2018; 38:387–389.
23. ■ Fotheringham J, Solis-Trapala I, Briggs V, *et al.* Catheter event rates in medical compared to surgical peritoneal dialysis catheter insertion. Kidney Int Rep 2023; 8:2635–2645.

This study demonstrated higher risk of early infection with the use of surgical technique, compared to medical (percutaneous) insertion of the PD catheter.

24. Agarwal A, Whitlock RH, Bamforth RJ, *et al.* Percutaneous versus surgical insertion of peritoneal dialysis catheters: a systematic review and meta-analysis. Can J Kidney Health Dis 2021; 8:20543581211052731.
25. Chow KM, Li PK, Cho Y, *et al.* ISPD catheter-related infection recommendations: 2023 update. Perit Dial Int 2023; 43:201–219.
26. Crabtree JH, Shrestha BM, Chow KM, *et al.* Creating and maintaining optimal peritoneal dialysis access in the adult patient: 2019 update. Perit Dial Int 2019; 39:414–436.
27. Crabtree JH, Burchette RJ. Comparative analysis of two-piece extended peritoneal dialysis catheters with remote exit-site locations and conventional abdominal catheters. Perit Dial Int 2010; 30:46–55.
28. Chan GC, Wong SH, Ng JK, *et al.* Risk of peritonitis after gastroscopy in peritoneal dialysis patients. Perit Dial Int 2022; 42:162–170.
29. Lockhart PB, Brennan MT, Sasser HC, *et al.* Bacteremia associated with toothbrushing and dental extraction. Circulation 2008; 117:3118–3125.
30. Yap DY, Chu WL, Ng F, *et al.* Risk factors and outcome of contamination in patients on peritoneal dialysis – a single-center experience of 15 years. Perit Dial Int 2012; 32:612–616.
31. Miles R, Hawley CM, McDonald SP, *et al.* Predictors and outcomes of fungal peritonitis in peritoneal dialysis patients. Kidney Int 2009; 76:622–628.
32. Michel C, Courdavault L, al Khayat R, *et al.* Fungal peritonitis in patients on peritoneal dialysis. Am J Nephrol 1994; 14:113–120.
33. Lo WK, Chan CY, Cheng SW, *et al.* A prospective randomized control study of oral nystatin prophylaxis for *Candida peritonitis* complicating continuous ambulatory peritoneal dialysis. Am J Kidney Dis 1996; 28:549–552.
34. Restrepo C, Chacon J, Manjarres G. Fungal peritonitis in peritoneal dialysis patients: successful prophylaxis with fluconazole, as demonstrated by prospective randomized control trial. Perit Dial Int 2010; 30:619–625.
35. Campbell D, Mudge DW, Craig JC, *et al.* Antimicrobial agents for preventing peritonitis in peritoneal dialysis patients. Cochrane Database Syst Rev 2017; 4:Cd004679.
36. Záruba K, Peters J, Jungbluth H. Successful prophylaxis for fungal peritonitis in patients on continuous ambulatory peritoneal dialysis: six years' experience. Am J Kidney Dis 1991; 17:43–46.
37. Davies SJ, Zhao J, Morgenstern H, *et al.* Low serum potassium levels and clinical outcomes in peritoneal dialysis-international results from PDOPPS. Kidney Int Rep 2021; 6:313–324.
38. Ribeiro SC, Figueiredo AE, Barretti P, *et al.* Low serum potassium levels increase the infectious-caused mortality in peritoneal dialysis patients: a propensity-matched score study. PLoS One 2015; 10:e0127453.
39. Pichitporn W, Kanjanabuch T, Phannajit J, *et al.* Efficacy of potassium supplementation in hypokalemic patients receiving peritoneal dialysis: a randomized controlled trial. Am J Kidney Dis 2022; 80:580.e1–588.e1.
40. Su CY, Pei J, Lu XH, *et al.* Gastrointestinal symptoms predict peritonitis rates in CAPD patients. Clin Nephrol 2012; 77:267–274.
41. Pérez-Fontan M, Machado Lopes D, García Enríquez A, *et al.* Inhibition of gastric acid secretion by H2 receptor antagonists associates a definite risk of enteric peritonitis and infectious mortality in patients treated with peritoneal dialysis. PLoS One 2016; 11:e0148806.
42. ■ Goldman S, Zhao J, Bieber B, *et al.* Gastric acid suppression therapy and its association with peritoneal dialysis-associated peritonitis in the peritoneal dialysis outcomes and practice patterns study (PDOPPS). Kidney360 2024; 5:370–379.

This study demonstrated higher risk of enteric PD-related peritonitis among gastric acid suppressants users.

43. Afsar B, Elsurer R, Bilgic A, *et al.* Regular lactulose use is associated with lower peritonitis rates: an observational study. Perit Dial Int 2010; 30:243–246.
44. Mirzai S, Rifai AO, Tidrick A, *et al.* A case report on pasteurella multocida peritoneal dialysis-associated peritonitis: when cats think medical equipment are toys. Case Rep Nephrol 2019; 2019:5150695.
45. Nishina M, Yanagi H, Koizumi M, *et al.* Pasteurella multocida peritonitis associated with a cat in a peritoneal dialysis patient using an automated cycler device. CEN Case Rep 2012; 1:73–76.
46. Makin AJ, Cartwright KA, Banks RA. Keeping the cat out of the bag: a hazard in continuous ambulatory peritoneal dialysis. BMJ 1991; 303:1610–1611.
47. Mu H, Yang M, Zhang Y, *et al.* Pet-related *Pasteurella multocida* induced peritonitis in peritoneal dialysis: a case report and review of the literatures. BMC Nephrol 2020; 21:102.
48. Kim I, Kim YW, Chung S, *et al.* Cat-induced *Pasteurella multocida* peritonitis in continuous ambulatory peritoneal dialysis. Kidney Res Clin Pract 2014; 33:65–67.
49. ■ Boudville N, McCullough K, Bieber B, *et al.* A different PET test: the relationship between pet ownership and peritonitis risk in the Peritoneal Dialysis Outcomes and Practice Patterns Study (PDOPPS). Perit Dial Int 2023; 43:263–267.

In this study, patients who owned both cats and dogs were shown to have an increased risk of PD-related peritonitis compared to patients with cats only, or those without pets.

50. ■ Bellanger Q, Lanot A, Lobbedez T, *et al.* The impact of cat-related peritonitis on peritoneal dialysis outcomes: Results from the RDPLF. Perit Dial Int 2023; 8968608231210130. [Online ahead of print]

This study showed no significant difference in mortality rates among patients who experienced cat-related peritonitis compared to those who experienced peritonitis due to other causes.

51. Nguyen DB, Arduino MJ, Patel PR. Hemodialysis-associated infections: chronic kidney disease. Dialysis Transplant 2019; 389.e8–410.e8.
52. Nassar GM, Ayus JC. Infectious complications of the hemodialysis access. Kidney Int 2001; 60:1–13.
53. Li PK, Chow KM. Infectious complications in dialysis – epidemiology and outcomes. Nat Rev Nephrol 2011; 8:77–88.
54. Perl J, Nessim SJ, Moist LM, *et al.* Vascular access type and patient and technique survival in home hemodialysis patients: the canadian organ replacement register. Am J Kidney Dis 2016; 67:251–259.
55. Trinh E, Chan CT. The burden of harm–what is the ideal vascular access for home hemodialysis? Clin J Am Soc Nephrol 2016; 11:205–206.
56. Abdul Salim S, Masoud AT, Thongprayoon C, *et al.* Systematic review and meta-analysis of antibiotic and antimicrobial lock solutions for prevention of hemodialysis catheter-related infections. ASAIO J 2021; 67:1079–1086.
57. Lok CE, Huber TS, Lee T, *et al.* KDOQI clinical practice guideline for vascular access: 2019 update. Am J Kidney Dis 2020; 75(Suppl 2): S1–S164.
58. Chan RJ, Chan CT. Vascular access considerations in home hemodialysis. Clin J Am Soc Nephrol 2024; 19:1036–1044.
59. MacRae JM, Ahmed SB, Atkar R, Hemmelgarn BR. A randomized trial comparing buttonhole with rope ladder needling in conventional hemodialysis patients. Clin J Am Soc Nephrol 2012; 7:1632–1638.
60. Wong B, Muneer M, Wiebe N, *et al.* Buttonhole versus rope-ladder cannulation of arteriovenous fistulas for hemodialysis: a systematic review. Am J Kidney Dis 2014; 64:918–936.
61. Muir CA, Kotwal SS, Hawley CM, *et al.* Buttonhole cannulation and clinical outcomes in a home hemodialysis cohort and systematic review. Clin J Am Soc Nephrol 2014; 9:110–119.
62. van Diepen AT, Tomlinson GA, Jassal SV. The association between exit site infection and subsequent peritonitis among peritoneal dialysis patients. Clin J Am Soc Nephrol 2012; 7:1266–1271.
63. Lloyd A, Tangri N, Shafer LA, *et al.* The risk of peritonitis after an exit site infection: a time-matched, case-control study. Nephrol Dial Transplant 2013; 28:1915–1921.
64. Lin J, Ye H, Li J, *et al.* Prevalence and risk factors of exit-site infection in incident peritoneal dialysis patients. Perit Dial Int 2020; 40:164–170.
65. Boudville N, Johnson DW, Zhao J, *et al.* Regional variation in the treatment and prevention of peritoneal dialysis-related infections in the peritoneal dialysis outcomes and practice patterns study. Nephrol Dial Transplant 2019; 34:2118–2126.
66. Grothe C, Taminato M, Belasco A, *et al.* Prophylactic treatment of chronic renal disease in patients undergoing peritoneal dialysis and colonized by *Staphylococcus aureus*: a systematic review and meta-analysis. BMC Nephrol 2016; 17:115.
67. Bernardini J, Bender F, Florio T, *et al.* Randomized, double-blind trial of antibiotic exit site cream for prevention of exit site infection in peritoneal dialysis patients. J Am Soc Nephrol 2005; 16:539–545.
68. Pierce DA, Williamson JC, Mauck VS, *et al.* The effect on peritoneal dialysis pathogens of changing topical antibiotic prophylaxis. Perit Dial Int 2012; 32:525–530.
69. Nessim SJ, Jassal SV. Gentamicin-resistant infections in peritoneal dialysis patients using topical gentamicin exit-site prophylaxis: a report of two cases. Perit Dial Int 2012; 32:339–341.
70. Chaiyakunapruk N, Veenstra DL, Lipsky BA, Saint S. Chlorhexidine compared with povidone-iodine solution for vascular catheter-site care: a meta-analysis. Ann Intern Med 2002; 136:792–801.
71. Jindal K, Chan CT, Deziel C, *et al.* Hemodialysis clinical practice guidelines for the Canadian Society of Nephrology. J Am Soc Nephrol 2006; 17(Suppl 1): S1–S27.
72. Levin A, Mason AJ, Jindal KK, *et al.* Prevention of hemodialysis subclavian vein catheter infections by topical povidone-iodine. Kidney Int 1991; 40:934–938.

73. O'Grady NP, Alexander M, Burns LA, *et al.* Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis 2011; 52:e162–e193.
74. Sesso R, Barbosa D, Leme IL, *et al.* Staphylococcus aureus prophylaxis in hemodialysis patients using central venous catheter: effect of mupirocin ointment. J Am Soc Nephrol 1998; 9:1085–1092.
75. Johnson DW, MacGinley R, Kay TD, *et al.* A randomized controlled trial of topical exit site mupirocin application in patients with tunnelled, cuffed haemodialysis catheters. Nephrol Dial Transplant 2002; 17: 1802–1807.
76. Apata IW, Kabbani S, Neu AM, *et al.* Opportunities to improve antibiotic prescribing in outpatient hemodialysis facilities: a report from the American Society of Nephrology and Centers for Disease Control and Prevention Antibiotic Stewardship White Paper Writing Group. Am J Kidney Dis 2021; 77:757–768.