Seminars in Dialysis

THIRTY YEARS: LESSONS LEARNED IN DIALYSIS

Changing Landscape for Peritoneal Dialysis: Optimizing Utilization

Martin J. Schreiber Jr
Clinical Affairs, Home Modalities, DaVita Kidney Care, DaVita Inc, Denver, Colorado

ABSTRACT

The future growth of peritoneal dialysis (PD) will be directly linked to the shift in US healthcare to a value-based payment model due to PD's lower yearly cost, early survival advantage over in-center hemodialysis, and improved quality of life for patients treating their kidney disease in the home. Under this model, nephrology practices will need an increased focus on managing the transition from chronic kidney disease to end-stage renal disease (ESRD), providing patient education with the aim of accomplishing modality selection and access placement ahead of dialysis initiation. Physicians must expand their knowledge base in home therapies and work toward increased technique survival through implementation of specific practice initiatives that highlight PD catheter placement success, preservation of residual renal function, consideration of incremental PD, and competence in urgent start PD. Avoidance of both early and late PD technique failures is also critical to PD program growth. Large dialysis organizations must continue to measure and improve quality metrics for PD, expand their focus beyond the sole provision of PD to holistic patient care, and initiate programs to reduce PD hospitalization rates and encourage physicians to consider the benefits of PD as an initial modality for appropriate patients. New and innovative strategies are needed to address the main reasons for PD technique failure, improve the connectivity of the patient in the home, leverage home biometric data to improve overall outcomes, and develop PD cycler devices that lower patient treatment burden and reduce both treatment fatigue and treatment-dependent complications.

The US healthcare system is shifting focus from the volume and profitability of services provided (physician visits, hospitalizations, procedures, and tests) to the patient outcomes achieved (1). Instead of rewarding volume, new value-based payment models reward better results in cost, quality, and outcome measures. Drivers prompting the shift to value-based payments in the US healthcare system include unsustainable costs; recognition that standard fee-for-service payments drive volume, not value; stakeholders' push for value; and federal government support for new payment approaches. There will be continued pressure to reduce costs and improve quality and outcomes; physician practices will need to start planning for this and a greater focus on the home as the preferred site for managing chronic disease will be necessary.

While patients with chronic disease make up only 20% of Medicare patients, they account for 80% of expenditures (2). Traditional fee-for-service models that pay for treatment transactions are ill-suited for managing patients who require close monitoring, frequent treatment adjustments, and coordinated management involving multiple different sites and personnel.

As a result of the movement to a value-based payment system, integrated kidney care (3) adoption will accelerate and require an increased focus on patient experience/patient-reported outcomes (4) and costs, regardless of whether physicians are participating in end-stage renal disease (ESRD) Seamless Care Organizations, Medicare Advantage special needs plans, Medicare Advantage capitation, or commercial shared savings. In addition, publicly reported data on specific metrics denoting practice-quality targets will enable comparisons between providers for patient and payer care decisions. DaVita has created a Patient-Focused Quality Pyramid to focus physicians and supporting medical personnel on a holistic patient-centered care approach as a primary way to improve quality patient survival (5).

Utilization management (6) ensures patients receive the right care at the right time—"appropriate care"—to improve clinical outcomes and lower costs (7). Coupling utilization management with disease management strategies can have a positive impact on how practices begin the process of understanding how to provide care for ESRD patients at reasonable cost and achieve targeted outcomes through more closely managing treatment decisions.

In ESRD care, extensive research shows that patients have better outcomes (longer lives and

Address correspondence to: Martin J. Schreiber Jr, MD, DaVita Inc, 2000 16th St, Denver, CO 80202, or e-mail: martin.schreiber@davita.com.

Seminars in Dialysis—Vol 30, No 2 (March–April) 2017
pp. 149–157
DOI: 10.1111/sdi.12576

fewer complications) when dialysis is started with peritoneal dialysis (PD) at home, or when hemodialysis (HD) is initiated with an arteriovenous fistula or graft rather than a central venous catheter (CVC). This is especially important in today's reimbursement environment because patients with optimal starts also cost tens of thousands of dollars less per year (8). In spite of this, more than half of US dialysis patients today start dialysis suboptimally, primarily as the result of initiation of HD with a CVC (9). A renewed emphasis on how patients start dialysis and how PD fits into the continuum of ESRD care will test a practice's infrastructure, physician knowledge base, and model of care delivery.

The current review will focus on understanding the historical growth of home dialysis, specific aspects of PD therapy that impact modality selection, challenges to optimize PD outcomes that require specific practice tracking and actions, and those innovations that could be applied to PD that would increase physician and patient confidence in the ability to manage ESRD in the home.

Historical Perspective: PD Home Modality Growth in the U.S

The recently published 2016 USRDS Annual Data Report noted that in 2013, 117,162 patients began ESRD therapy in the United States; of these only 10,562 started on PD while 103,382 initiated in-center hemodialysis (ICHD) (10). At the end of 2013, a total of 408,859 ESRD patients were being treated with HD (90%), while 45,258 patients (9.9%) were receiving PD. The use of home hemodialysis (HHD) was 35% higher in 2012 than in 2002, but still accounts for a minority of patients requiring ESRD therapy. More recent data show that, as of 2016, the 10 largest US dialysis organizations treated 432,805 dialysis patients in 5474 units; 41,624 were on PD, 6932 were on HHD, and 380,892 received ICHD. Thus, while there has been growth in home dialysis, the vast majority of patients (88%) were still receiving ICHD as of 2016 (11).

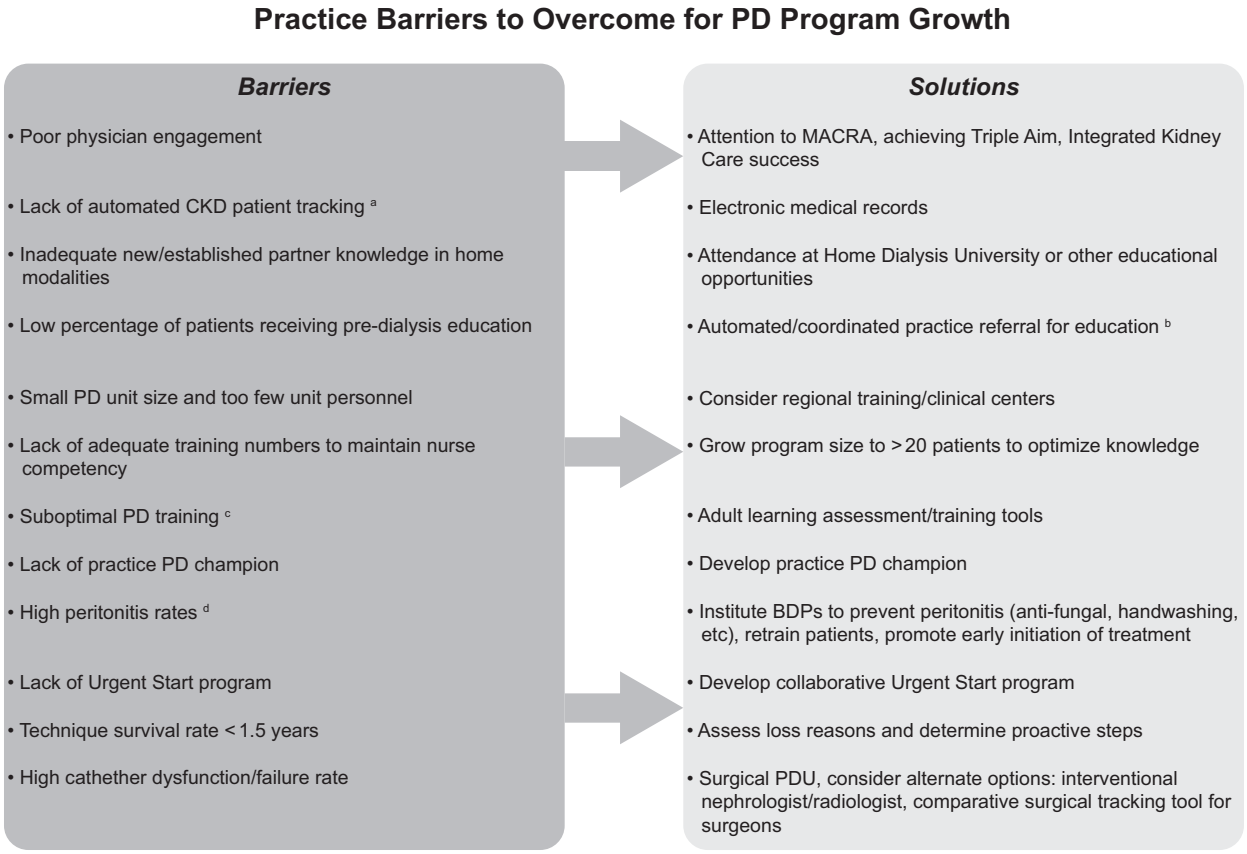
The Medicare ESRD program has attempted to incentivize home dialysis through different payment methods, including identical payments for physicians and providers for ICHD and PD services; waiving of the 90-day waiting period for new uninsured Medicare-eligible but uncovered ESRD patients starting home dialysis; a one-time physician payment for overseeing home modality training; and physician reimbursement for a monthly patient face-to-face clinic visit equivalent to 2–3 monthly visits for ICHD patients. However, these incentives have not changed the low utilization of home modalities (12–14). Despite the reported early survival advantage for PD compared to ICHD, and the equivalence of PD to ICHD with respect to all-cause and cause-specific mortality, hospitalizations, infection-related complications, and quality of life, there has not been the modality growth that one might have expected (15–20).

Managing the CKD to ESRD Transition: Required Nephrology Practice Considerations

The changing healthcare landscape will require practices to design an infrastructure that promotes the concept of integrated kidney care in which the nephrologist uses PD, HD, and transplantation as complementary therapies. The choice of the initial therapy should be unbiased; all options must be available (21). Most patients will require more than one therapy during their ESRD life, and transitions from one to another should be planned and carefully managed. Several interventions (e.g., kidney health and dialysis options education, shared decision-making, urgent start etc.) should be adopted by practices as they move forward in an integrated kidney care environment wherein home modalities become a critical ESRD starting point (22). To successfully navigate the transition of patients from CKD to ESRD, nephrology practices need to address potential barriers to PD growth with their entire group, department, or health care organization (Fig. 1).

A recent report from the ARO (Analyzing data, Recognizing excellence, Optimizing outcomes) CKD Research Initiative (23) highlights the importance of timely modality selection and preparation of patients by the nephrology practice, especially for PD consideration, prior to starting ICHD: In an analysis of 11,244 incident patients presenting to over 300 Fresenius Medical Care dialysis centers in 14 European countries and Turkey, a total of 2405 cardiovascular (CV) events in 1449 patients were reported to have occurred within 2 years of dialysis initiation (24), with the event rate peaking during the first week of ICHD then declining until week 4. This study demonstrates that the period immediately following dialysis initiation is a very high risk period, characterized by a much higher rate of major CV events than the remainder of the first 2 years. While in conjecture, the authors suggested that a deterioration in renal function may play a role in volume-related events; this is coupled with the possibility that the HD procedure itself may trigger CV events in certain patients.

Peritoneal dialysis utilization rates need to be viewed in the context of chronic disease management schemes focused on the required steps for optimal quality survival along the continuum of care. Therefore, renal replacement therapy approaches must be designed around patient clinical risk, avoidance of further end-organ damage, quality of life, and achievement of quality survival. This will require working more closely with primary care practices to better track patients with progressive renal failure.



[a] Ability to identify at-risk patients (eGFR <30 mL/min/1.73m^2) in practice or hospital
[b] Continue education until patient can choose an access
[c] Too few training days (< 8), lack of adult training experience, inflexible trainer
[d] > 0.5 episodes per patient year at risk

FIG. 1. Practice barriers to overcome and solutions to consider for PD program growth.

Positioning Modality Selection Within An Integrated Kidney care Environment

Appropriate preparedness remains a barrier to more widespread utilization of PD for new patients in the United States. (25) Insufficient reimbursement for education discourages practices from prioritizing ESRD education, but other factors play a role as well. Physicians may not have the time in a busy office schedule to educate; nephrology practices may not totally embrace educational programs offered by large dialysis organizations (LDOs), yet not have a structured program themselves; short office sessions may be insufficient to achieve adequate education; and lack of experience or confidence in PD may prevent effective discussion of this option with patients and families. The opinions of ICHD nurses toward home modalities can also have a negative impact on PD growth (26). As noted in a previous publication (27) and depicted in Fig. 2, successful preparation of patients requires several important components. A number of studies have demonstrated that with appropriate education, a significant proportion (30–50%) of patients without a contraindication would select PD over ICHD (28,29). The first therapy choice is critical since patients rarely transition to a home therapy like PD after initiating ICHD (30), even though there may be specific clinical advantages in doing so.

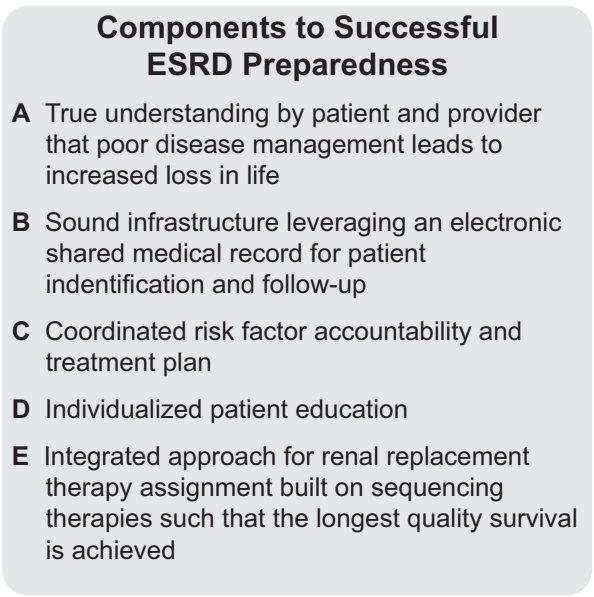


FIG. 2. Components to successful ESRD preparedness.

Education programs provided by LDOs can complement physician practice education and even be applied upstream as a service to primary care practices in conjunction with the nephrologist.

Collaboratively building patient life plans strengthens patients' realization of the important role they play in ensuring stability of their health and the opportunities available if they are successful. The new ESRD care model focuses on education, engagement, and a commitment to developing a life plan with the patient. The life planning exercise utilizes several different health care team members to guide the patient through the seven steps of the exercise. Individualizing the proper sequence of options for renal replacement therapy to achieve the longest quality survival, while preserving subsequent future treatment options, is a critical goal for the life planning exercise. There are a number of factors that are key to the development of a successful life plan, including defining the patient's role in successful management, avoiding, and/or controlling risk, establishing which healthcare provider will monitor each specific comorbidity, determining the optimal sequence of renal replacement options for the individual patient, and determining how progress on treatment will be monitored.

The education team plays a key role in assessing a patient's potential for the initial dialysis therapy. Those factors warranting consideration during the decision process include patient age, socio-demographic status, comorbidity burden, residential location (rural vs. urban), physician practice dialysis support infrastructure, physician knowledge, and comfort with PD. Patients are particularly vulnerable during the first 90 days after dialysis initiation and need intensive management during this period. Older patients and those with diabetes, previous HD treatment, or failed transplant may be at a higher risk of technique failure and hence deserve special attention (e.g., more frequent clinic visits and unit contact following training).

Clinical Considerations in PD Home Modality Selection for Program Growth

Achieving sustainable PD program growth will require the treating nephrologist and support personnel to focus attention on several key facets of PD initiation and ongoing patient care.

Residual Renal Function

Residual renal function (RRF) has been demonstrated to impact survival of PD patients (31); PD has a positive effect on preservation of RRF (32) and partial regression of left ventricular remodeling. RRF decline during the first year of dialysis has a graded association with all-cause mortality among incident hemodialysis patients, suggesting that programs should focus on strategies to preserve RRF as a priority activity (33). A number of strategies for preserving RRF have been explored (34), including increasing/maintaining urine output, dietary intervention, blood pressure control, renin–angiotensin–aldosterone system blockade, PD submodality effect with increased glucose load, icodextrin usage, avoiding intravascular volume depletion and nephrotoxic insults.

Incremental PD

It has recently been suggested that an initial incremental approach to dialysis might help preserve residual renal function through an intact nephron hypothesis in reverse (35). Incremental PD can also be viewed as a bridge to either cadaveric- or living-related renal transplantation (36) with the potential for improved quality of life and less treatment burden due to the non–full-dose PD prescription (37). A significant reduction in loss of glomerular filtration rate in the incremental dialysis period vs. that which was observed in the predialysis period was also observed.

Urgent Start Program

Late referral to the nephrologist typically results in emergent start dialysis, usually with ICHD using a tunneled CVC as the default therapy. A number of reports have noted better outcomes for patients who are started on PD with a PD catheter rather than ICHD with a CVC. A propensity-matched comparison (376 patients) of urgent start PD vs. urgent CVC HD, in a structured urgent start program demonstrated 51% lower mortality, 39% lower rate of hospitalization, and a 42% lower rate of infections for urgent start PD patients (38).

Considering the risks that a CVC poses for both serious infection and mortality, leveraging a peritoneal catheter access with emergent initiation of PD rather than HD has gained increasing attention over the last several years (39). This approach allows for expedited placement of a PD catheter and initiation of PD therapy within 24 hours to days following placement.

The urgent placement of the PD catheter by a surgeon, interventional nephrologist, or interventional radiologist is critical for the urgent start program to succeed. Additional components include adequate hospital resources, with awareness for this approach by ER physicians, cardiologists, hospitalists, nursing staff, and discharge planners; dialysis unit space and materials; design of prescriptions for dialysis performed in the supine position; and ability to transition from the urgent start in a hospital setting, to training for home dialysis (40). Several studies have demonstrated the safety of this approach, increased patient survival, and satisfactory technique survival (41).

Optimizing Peritoneal Dialysis Catheter Placement

Marked variability in catheter insertion techniques and perioperative management may impact

catheter and patient outcomes and warrants further study (42). Timely catheter placement and a functional long-term peritoneal access are critically important to optimally preparing and maintaining patients on PD (43). While operator expertise is a critical component to successful catheter placement, each type of placement procedure—whether minlaparotomy, advanced laparoscopy, or percutaneous needle guide wire with or without fluoroscopic imaging—yields comparable results when adhering to best demonstrated practices for each implantation procedure. One study examining advanced laparoscopic placement reported that the cumulative revision-free and assisted catheter survival probabilities at 5 years were 0.96 and 0.99, respectively (44). The incidence of pericatheter leak was 2.6% and there were no occurrences of pericatheter hernia or subcutaneous cuff extrusion. Laparoscopic salvage procedures limited losses from mechanical catheter problems to 0.9%. Catheter survival should be tracked and if operators are not able to achieve acceptable catheter survival rates based on reported data then a reassessment of technique or operator should be considered.

Addressing Technique Survival in Nephrology Practices

While new patient growth is critical to program stability, patient drop-out from PD, both early (within 90 days) and late (>6 months after training), has a significant impact on sustaining PD program growth. The rate of PD technique failure is at its highest during the early months after treatment initiation and decreases later due to fewer catheter and abdominal complications and reduced influence of psychological factors following adaptation to PD (45). Practices need to identify patient risk for early and late drop-out and provide more intensive support posttraining than has been customary. Activities that a program should consider to decrease the risk for drop-out within 90 days are shown in Fig. 3.

A number of studies have demonstrated the need for practices to examine their individual program reasons for technique failure and take steps to effectively optimize results. One study assessed 709 incident PD patients participating in the Netherland Cooperative Study on the Adequacy of Dialysis (NECOSAD), who started treatment between 1997 and 2007 (45). Four separate time frames post-PD initiation were considered: 0–3 months, 3–12 months, 12–24 months, and 24–36 months; risk of switching was found to be greatest during the first 3 months and decreased thereafter.

It has been reported that technique failure is more likely to occur during the first 6 months of PD in patients who are treated with HD prior to PD, who start PD after allograft failure, or who develop peritonitis within the first 6 months of therapy (46). Additionally, unit size, nurse experience, training duration, and poor fellowship training have been reported to play a role (47). Seemingly, catheter dysfunction and psychological problems are major reasons for early loses with peritonitis, while ultrafiltration failure, malnutrition, and dialysis inadequacy are responsible for late drops (48). Proactive strategies as depicted in Fig. 4 can be of value in decreasing the rate of early and late technique failure due to peritonitis.

A study of the risk of PD technique failure in 13,120 patients identified from the Canadian Organ Replacement Register and divided into two different

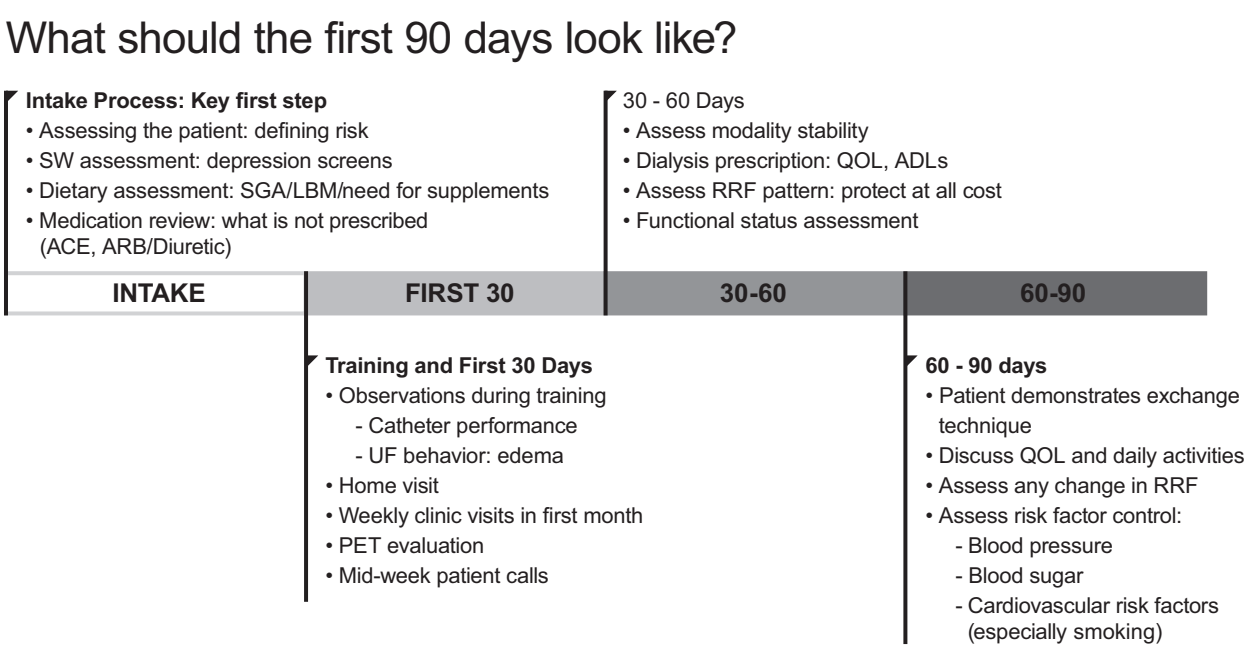


FIG. 3. The first 90 days require a cadence of timed activities to optimize technique survival.

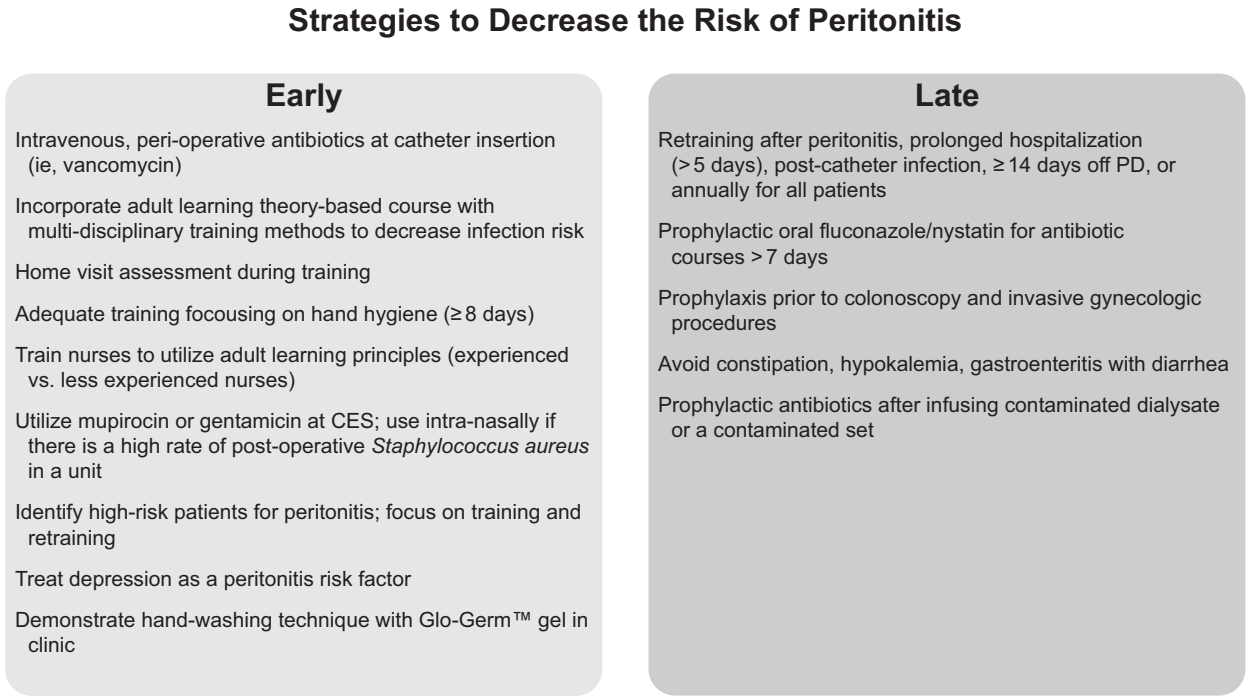


FIG. 4. Strategies to decrease the risk of peritonitis.

time cohorts, 2001–2005 ($N = 4316$) and 2006–2009 ($N = 3621$) revealed that, while patient survival on PD has improved over the last decade, there has been only modest change in technique failure rates, with a trend toward a reduction in late technique failure (49). In a study of four large cohorts of patients initiating PD in 2000–2003 the major causes of transfer to HD included infection (28%), catheter problems (17%), inadequate dialysis (16%), and psycho-social issues (15%) (50). Center characteristics correlated with catheter problems, inadequate dialysis, and infectious complications.

The strategies aimed at prolonging PD technique survival will require an ongoing emphasis on reducing the risk of peritonitis-related technique failure, as well as a better understanding of the contribution of noninfectious etiologies—for example, catheter placement issues, psycho-social surveillance, loss of RRF, and patient-specific CAPD vs. APD (submodality) on technique failure. Vigilance during the early weeks following training is critical to avoid early drops.

Peritonitis Tracking and Prevention

Peritonitis remains a major reason for hospitalization and subsequent transfer from PD to ICHD or HHD. PD-related infections are associated with both nonmodifiable and modifiable risk factors (51). Nonmodifiable factors include ethnicity (African Americans (52)), age, sex, diabetes, underlying renal disease (systemic lupus) while modifiable factors include malnutrition, being overweight, smoking, *Staphylococcus* infection, socioeconomic status, prior HD, and depression.

Peritoneal dialysis programs should ensure that the International Society for Peritoneal Dialysis (ISPD) guidelines are a critical part of their peritonitis prevention and treatment platforms (53). Preventive strategies for avoiding peritonitis are critical (54,55). DaVita has recently instituted a *6 business rule* peritonitis surveillance system, which monitors peritonitis rates throughout DaVita U.S. PD programs. The DaVita peritonitis target for U.S. PD programs is one episode in 52 months with a current overall rate of 1:50 months. Increasing awareness of how like-sized units compare, coupled with implementation of standardized processes of care should lead to continued improvements in overall rates of peritonitis and reduce the rate of infectious hospitalizations.

Hospitalizations and Readmissions

Hospitalizations pose a unique risk for technique failure in PD patients. According to the 2016 USRDS Annual Data Report, the decline in hospitalizations due to infection (11.4% overall) was more pronounced among patients on PD (15.4%), and those with a transplant (14.2%) compared to HD patients (11.7%). Targeted interventions to prevent and reduce infection rates, especially among PD patients, have had a significant positive effect. Among dialysis patients, readmissions are associated with increased morbidity, mortality, and reduced quality of life.

In a comparison of dialysis-related hospitalization risk among daily home hemodialysis (DHD) and PD patients, hospitalization rate was found to be

higher in the PD group (of which 68% were on CAPD and 32% on APD) (56). It remains unclear what role the predominance of CAPD patients had on the outcome, but the proportion of CAPD vs. APD is distinctly different in this study vs. that observed in the United States. Following hospitalization, 15% of the DHD group, compared with 44% of the PD group, switched back to ICHD, emphasizing the importance of avoiding hospitalizations for home patients.

Another analysis comparing 4201 new HHD patients and 4201 new PD patients from the USRDS demonstrated an 8% lower risk for all-cause hospitalization and a 37% lower rate of technique failure for the HHD study group (57). Hospitalization risk comparisons favored HHD with respect to cardiovascular disease and dialysis access infection and PD with respect to blood stream infection. The higher observed rate of PD patient admissions for cardiovascular reasons has been reported in several studies and warrants further review and closer PD patient monitoring.

In PD patients, volume and blood pressure should be closely monitored and effectively addressed to avoid both an increase in left ventricular mass index and an increase in cardiothoracic ratio (58). Volume-based PD prescriptions incorporating icodextrin rather than glucose in the long dwell reduced the complexity of PD regimens, total glucose exposure, and 24-hour total treatment solution volumes (59).

Infection- related PD hospitalizations account for a significant percentage of hospitalizations overall. The main risk factors for infection-related hospitalization that programs should focus on include fungal peritonitis, elevated peritoneal white blood cell count at 72 hours, concurrent tunnel infection, polymicrobial peritonitis (60), inability to perform self-care, and age greater than 80 years (61).

Preventing hospitalizations and readmissions necessitates the development of infrastructure to manage inter-current illnesses in a timely fashion outside the hospital emergency room (62).

Large Dialysis Organizations and Nonemployed Physician Practices in the United States

Reimagining the ways in which LDOs partner with physicians to manage kidney disease is critical to providing high-value care to every patient. DaVita's emphasis on a Patient-Focused Quality Pyramid (63) represents a holistic approach to patient-centered care. This approach expands beyond the traditional focus on providing the highest quality dialysis to additionally include managing risk factors and optimizing patient experience. Despite continually highlighting the importance of patient education in enabling patients to treat their kidney disease at home, discussing and reporting on quality target results in PD, and providing the infrastructure built around a standardization of practice processes, what has become clear is that physician engagement (64) is at the core of accomplishing a "needs of the patient come first" goal, especially for home modalities. This shared purpose should play a major role in nephrologists dedicating the time and energy it takes to help patients optimally transition from CKD to ESRD. This will require a transformation from a process organized around individual physicians to a team-based approach, which can effectively determine a patient's ability to successfully pursue home dialysis.

As observed with the care of congestive heart failure patients, the optimization of outcomes and increased utilization of best demonstrated practices in PD will require practices to reduce defects in the six dimensions of care management identified by the Institute of Medicine: safety, effectiveness, patient-

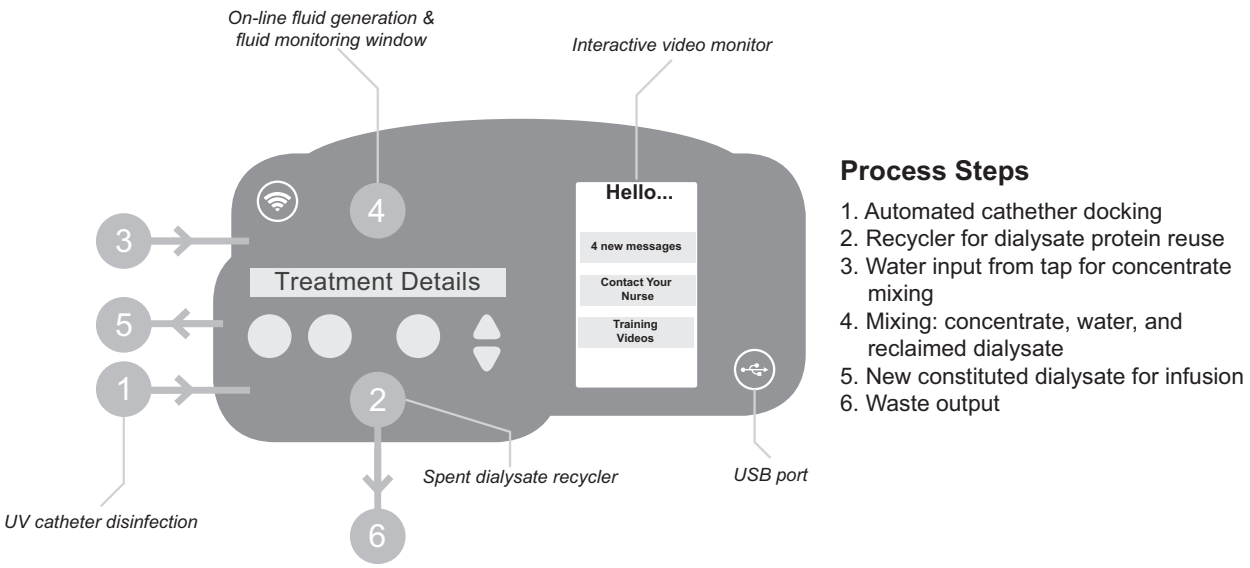


FIG. 5. Innovative considerations for future PD cycler devices.

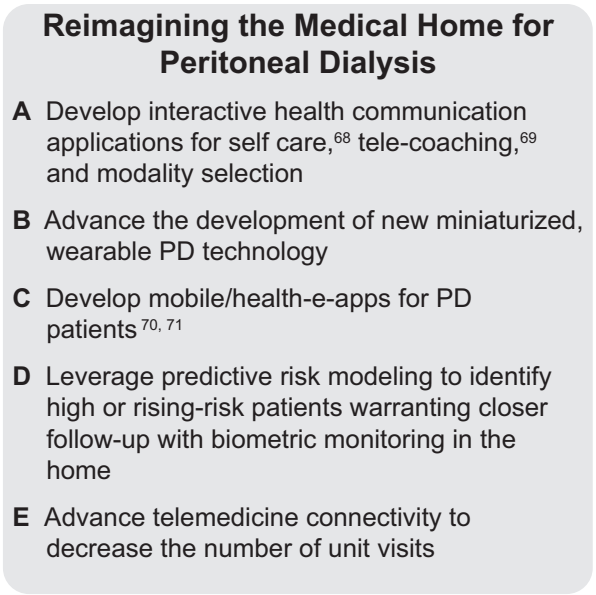


FIG. 6. Reimagining the medical home for peritoneal dialysis.

centeredness, timeliness, efficiency, and equity (65). Currently there are too few efforts to effectively address the defects in care across the continuum of ESRD care, especially in PD, by physician practices, providers, and specialty organizations.

Dialysis providers will continue to work with physician practices to align PD practice goals with the Triple Aim: improving the individual experience of care; improving the health of complex populations (i.e., PD patients); and reducing the per capita costs of care for ESRD patients overall (66). This will require LDOs to listen to physicians' concerns regarding PD, to create processes that nephrologists can help shape around PD, and to share practice-specific dashboard data to demonstrate how operational changes can impact PD patient outcomes. A true "group action" is needed to move beyond the status quo for PD in the future. We definitely can do better.

Innovations Required To Drive Future PD Growth

The low utilization rate for incident ESRD patients, patient and family burden, and the high technique failure rate are major reasons why PD has not grown consistently and at a greater rate than it has over the last two decades. A PD growth strategy must determine how innovations will provide value for patients deciding to manage their kidney disease at home, lower the burden on patients and families and improve time on therapy. Dialysis providers, manufacturers of PD direct supplies and ancillary devices, and independent inventors need to align activities around common priorities that can drive consistent PD growth.

Strategic innovations in PD should focus on a redesign of the current PD technology platform (Fig. 5); creating modality decision programs to more accurately assist the patient in modality selection; integrating technology that enables healthcare providers to extend the home dialysis program into the actual patient's home (e.g. DaVita Home Connect); deploying technology solutions for capturing and analyzing data from high risk and rising risk patients (67); leveraging of telemedicine/e-health advances that lower patient and care partner burden; and improving technique survival (time on therapy) through attention to the main areas resulting in patient loss. Figure 6 depicts how interactive approaches generate both excitement and confidence in a patient's ability to manage their kidney disease at home (68–71).

Conclusion

The changing healthcare landscape will force nephrology practices to redesign how patients transition from CKD to ESRD therapies and how renal replacement therapies are sequenced to optimize patient outcomes, control costs, and provide great patient experience. Championing patient education that fosters decisions based on clinical risk factor control as well as patient-centered views is important. For PD to grow, there needs to be an increased focus on why PD should be the first therapy and how to extend time on therapy. Innovation, both incremental and disruptive, has the potential to redesign how patients with ESRD can be optimally managed in the home setting on PD.

References

1. Porter ME, Lee TH: The strategy that will fix health care. *Harv Bus Rev* 91:50–70, 2013
2. Cohen N, van de Craen D, Stamenovic A, Lagor C: The importance of home and community-based settings in population health management. *Phillips Home Monitoring* March:1–11, 2013
3. Valentijn PP, Biermann C, Bruijnzeels MA: Value-based integrated (renal) care: setting a development agenda for research and implementation strategies. *BMC Health Serv Res* 16:330, 2016
4. Porter I, Goncalves-Bradley D, Ricci-Cabello I, Gibbons C, Ganganagaripalli J, Fitzpatrick R, et al.: Framework and guidance for implementing patient-reported outcomes in clinical practice: evidence, challenges and opportunities. *J Comp Eff Res* 5:507–519, 2016
5. Nissenson AR: Improving outcomes for ESRD patients: shifting the quality paradigm. *Clin J Am Soc Nephrol* 9:430–434, 2014
6. Bailit HL, Sennett C: Utilization management as a cost-containment strategy. *Health Care Financ Rev* 1991:87–93, 1992
7. Fireman B, Bartlett J, Selby J: Can disease management reduce health care costs by improving quality? *Health Aff (Millwood)* 23:63–75, 2004
8. Kaplan RS, Haas DA: How not to cut health care costs. *Harv Bus Rev* 92: 116–122, 142, 2014
9. Mendelssohn DC, Curtis B, Yeates K, Langlois S, MacRae JM, Semeniuk LM, et al.: Suboptimal initiation of dialysis with and without early referral to a nephrologist. *Nephrol Dial Transplant* 26:2959–2965, 2011
10. Saran R, Li Y, Robinson B, Abbott KC, Agodoa LY, Ayanian J, et al.: US Renal Data System 2015 Annual Data Report: epidemiology of Kidney Disease in the United States. *Am J Kidney Dis* 67: Svii, S1–305, 2016
11. Neumann ME: Poised for change. *NNI* 30:26–27, 2016
12. Hornberger J, Hirth RA: Financial implications of choice of dialysis type of the revised Medicare payment system: an economic analysis. *Am J Kidney Dis* 60:280–287, 2012
13. Mehrotra R, Devuyst O, Davies SJ, Johnson DW: The current state of peritoneal dialysis. *J Am Soc Nephrol* 27:3238–3252, 2016

14. Rivara MB, Mehrotra R: The changing landscape of home dialysis in the United States. *Curr Opin Nephrol Hypertens* 23:586–591, 2014
15. Brown EA, Johansson L, Farrington K, Gallagher H, Sensky T, Gordon F, et al.: Broadening Options for Long-term Dialysis in the Elderly (BOLDE): differences in quality of life on peritoneal dialysis compared to haemodialysis for older patients. *Nephrol Dial Transplant* 25:3755–3763, 2010
16. Juergensen E, Wuerth D, Finkelstein SH, Juergensen PH, Bekui A, Finkelstein FO: Hemodialysis and peritoneal dialysis: patients' assessment of their satisfaction with therapy and the impact of the therapy on their lives. *Clin J Am Soc Nephrol* 1:1191–1196, 2006
17. Mehrotra R, Chiu YW, Kalantar-Zadeh K, Bargman J, Vonesh E: Similar outcomes with hemodialysis and peritoneal dialysis in patients with end-stage renal disease. *Arch Intern Med* 171:110–118, 2011
18. Vonesh EF, Snyder JJ, Foley RN, Collins AJ: Mortality studies comparing peritoneal dialysis and hemodialysis: what do they tell us? *Kidney Int Suppl* 103:S3–11, 2006
19. Weinhandl ED, Foley RN, Gilbertson DT, Arneson TJ, Snyder JJ, Collins AJ: Propensity-matched mortality comparison of incident hemodialysis and peritoneal dialysis patients. *J Am Soc Nephrol* 21:499–506, 2010
20. Yeates K, Zhu N, Vonesh E, Trpeski L, Blake P, Fenton S: Hemodialysis and peritoneal dialysis are associated with similar outcomes for end-stage renal disease treatment in Canada. *Nephrol Dial Transplant* 27:3568–3575, 2012
21. Davies SJ, Van Biesen W, Nicholas J, Lameire N: Integrated care. *Perit Dial Int* 21(Suppl. 3):S269–274, 2001
22. Tuso P: Choosing wisely and beyond: shared decision making and chronic kidney disease. *Perm J* 17:75–78, 2013
23. Floege J, Gillespie IA, Kronenberg F, Anker SD, Gioni I, Richards S, et al.: Development and validation of a predictive mortality risk score from a European hemodialysis cohort. *Kidney Int* 87:996–1008, 2015
24. Eckardt KU, Gillespie IA, Kronenberg F, Richards S, Stenvinkel P, Anker SD, et al.: High cardiovascular event rates occur within the first weeks of starting hemodialysis. *Kidney Int* 88:1117–1125, 2015
25. Qamar M, Bender F, Rault R, Piraino B: The United States' perspectives on home dialysis. *Adv Chronic Kidney Dis* 16:189–197, 2009
26. Phillips M, Wile C, Bartol C, Stockman C, Dhir M, Soroka SD, et al.: An education initiative modifies opinions of hemodialysis nurses towards home dialysis. *Can J Kidney Health Dis* 2:16, 2015
27. Schreiber M, Golper TA: Assessing and preparing the patient for future ESRD modalities. In: Fadem S (ed.). *Essentials of Chronic Kidney Disease*. New York, NY: Nova BioMedical (Nova Science Publishers, Inc.), 2015:293–304
28. Korevaar JC, Feith GW, Dekker FW, van Manen JG, Boeschoten EW, Bossuyt PM, et al.: Effect of starting with hemodialysis compared with peritoneal dialysis in patients new on dialysis treatment: a randomized controlled trial. *Kidney Int* 64:2222–2228, 2003
29. Mehrotra R, Marsh D, Vonesh E, Peters V, Nissenson A: Patient education and access of ESRD patients to renal replacement therapies beyond in-center hemodialysis. *Kidney Int* 68:378–390, 2005
30. Rubin HR, Fink NE, Plantinga LC, Sadler JH, Kliger AS, Powe NR: Patient ratings of dialysis care with peritoneal dialysis vs hemodialysis. *JAMA* 291:697–703, 2004
31. Rebic D, Matovinovic MS, Rasic S, Kes P, Hamzic-Mehmedbasic A: The effect of preserved residual renal function on left ventricular structure in non-anuric peritoneal dialysis patients. *Kidney Blood Press Res* 40:500–508, 2015
32. He L, Liu X, Li Z, Abreu Z, Malavade T, Lok CE, et al.: Rate of decline of residual kidney function before and after the start of peritoneal dialysis. *Perit Dial Int* 36:334–339, 2016
33. Obi Y, Rhee CM, Mathew AT, Shah G, Streja E, Brunelli SM, et al.: Residual kidney function decline and mortality in incident hemodialysis patients. *J Am Soc Nephrol* 27:3758–3768, 2016
34. Nongnuch A, Assanatham M, Panorchan K, Davenport A: Strategies for preserving residual renal function in peritoneal dialysis patients. *Clin Kidney J* 8:202–211, 2015
35. Golper TA, Mehrotra R: The intact nephron hypothesis in reverse: an argument to support incremental dialysis. *Nephrol Dial Transplant* 30:1602–1604, 2015
36. Domenici A, Comunian MC, Fazzari L, Sivo F, Dinnella A, Della Grotta B, et al.: Incremental peritoneal dialysis favourably compares with hemodialysis as a bridge to renal transplantation. *Int J Nephrol* 2011:204–216, 2011
37. Viglino G, Neri L, Barbieri S: Incremental peritoneal dialysis: effects on the choice of dialysis modality, residual renal function and adequacy. *Kidney Int Suppl* 108:S52–55, 2008
38. Ghaffari A, Brunelli SM, Cassin M, Schreiber M: Urgent-start peritoneal dialysis versus urgent-start hemodialysis: a multicenter clinical trial. *Kidney Week*. Philadelphia, PA, JASN, 2014
39. Arramreddy R, Zheng S, Saxena AB, Liebman SE, Wong L: Urgent-start peritoneal dialysis: a chance for a new beginning. *Am J Kidney Dis* 63:390–395, 2014
40. Ghaffari A, Kumar V, Guest S: Infrastructure requirements for an urgent-start peritoneal dialysis program. *Perit Dial Int* 33:611–617, 2013
41. Alkatheeri AM, Blake PG, Gray D, Jain AK: Success of urgent-start peritoneal dialysis in a large Canadian renal program. *Perit Dial Int* 36:171–176, 2016
42. Wallace EL, Fissell RB, Golper TA, Blake PG, Lewin AM, Oliver MJ, et al.: Catheter insertion and perioperative practices within the ISPD North American Research Consortium. *Perit Dial Int* 36:382–386, 2016
43. Crabtree JH: Peritoneal dialysis catheter implantation: avoiding problems and optimizing outcomes. *Semin Dial* 28:12–15, 2015
44. Crabtree JH, Burchette RJ: Effective use of laparoscopy for long-term peritoneal dialysis access. *Am J Surg* 198:135–141, 2009
45. Kolesnyk I, Dekker FW, Boeschoten EW, Krediet RT: Time-dependent reasons for peritoneal dialysis technique failure and mortality. *Perit Dial Int* 30:170–177, 2010
46. Bechade C, Guittet L, Evans D, Verger C, Ryckelynck JP, Lobbedez T: Early failure in patients starting peritoneal dialysis: a competing risks approach. *Nephrol Dial Transplant* 29:2127–2135, 2014
47. Lobbedez T, Boissinot L, Ficheux M, Castrale C, Ryckelynck JP: How to avoid technique failure in peritoneal dialysis patients? *Contrib Nephrol* 178:53–57, 2012
48. Descoeudres B, Koller MT, Garzoni D, Wolff T, Steiger J, Schaub S, et al.: Contribution of early failure to outcome on peritoneal dialysis. *Perit Dial Int* 28:259–267, 2008
49. Perl J, Wald R, Bargman JM, Na Y, Jassal SV, Jain AK, et al.: Changes in patient and technique survival over time among incident peritoneal dialysis patients in Canada. *Clin J Am Soc Nephrol* 7:1145–1154, 2012
50. Mujais S, Story K: Peritoneal dialysis in the US: evaluation of outcomes in contemporary cohorts. *Kidney Int Suppl* 103:S21–26, 2006
51. Kerschbaum J, Konig P, Rudnicki M: Risk factors associated with peritoneal-dialysis-related peritonitis. *Int J Nephrol* 2012:483250, 2012
52. Wang Q, Bernardini J, Piraino B, Fried L: Albumin at the start of peritoneal dialysis predicts the development of peritonitis. *Am J Kidney Dis* 41:664–669, 2003
53. Li PK, Szeto CC, Piraino B, de Arteaga J, Fan S, Figueiredo AE, et al.: ISPD peritonitis recommendations: 2016 update on prevention and treatment. *Perit Dial Int* 36:481–508, 2016
54. Campbell DJ, Brown FG, Craig JC, Gallagher MP, Johnson DW, Kirkland GS, et al.: Assessment of current practice and barriers to antimicrobial prophylaxis in peritoneal dialysis patients. *Nephrol Dial Transplant* 31:619–627, 2016
55. Campbell DJ, Johnson DW, Mudge DW, Gallagher MP, Craig JC: Prevention of peritoneal dialysis-related infections. *Nephrol Dial Transplant* 30:1461–1472, 2015
56. Suri RS, Li L, Nesrallah GE: The risk of hospitalization and modality failure with home dialysis. *Kidney Int* 88:360–368, 2015
57. Weinhandl ED, Gilbertson DT, Collins AJ: Mortality, hospitalization, and technique failure in daily home hemodialysis and matched peritoneal dialysis patients: a matched cohort study. *Am J Kidney Dis* 67:98–110, 2016
58. Lai S, Molfino A, Russo GE, Testorio M, Galani A, Innico G, et al.: Cardiac, inflammatory and metabolic parameters: hemodialysis versus peritoneal dialysis. *Cardiorenal Med* 5:20–30, 2015
59. Akonur A, Firanek CA, Gellens ME, Hutchcraft AM, Kathuria P, Sloand JA: Volume-based peritoneal dialysis prescription guide to achieve adequacy targets. *Perit Dial Int* 36:188–195, 2016
60. van Esch S, Krediet RT, Struijk DG: Prognostic factors for peritonitis outcome. *Contrib Nephrol* 178:264–270, 2012
61. Quintanar Lartundo JA, Palomar R, Dominguez-Diez A, Salas C, Ruiz-Criado J, Rodrigo E, et al.: Microbiological profile of peritoneal dialysis peritonitis and predictors of hospitalization. *Adv Perit Dial* 27:38–42, 2011
62. Wish JB: The role of 30-day readmission as a measure of quality. *Clin J Am Soc Nephrol* 9:440–442, 2014
63. Nissenson AR: Delivering better quality of care: relentless focus and starting with the end in mind at DaVita. *Semin Dial* 29:111–118, 2016
64. Lee TH, Cosgrove T: Engaging doctors in the health care revolution. *Harv Bus Rev* 92: 104–111, 138, 2014
65. Crossing the Quality Chasm: A New Health System for the 21st Century. Institute of Medicine Committee on Quality of Healthcare in America. Washington, DC: National Academic Press (US), 2001.
66. Berwick DM, Nolan TW, Whittington J: The triple aim: care, health, and cost. *Health Aff (Millwood)* 27:759–769, 2008
67. Handmaker K, Hart J: 9 steps to effective population health management. *Healthc Financ Manage* 69:70–76, 2015
68. Driscoll A, Davidson P, Clark R, Huang N, Aho Z: Tailoring consumer resources to enhance self-care in chronic heart failure. *Aust Crit Care* 22:133–140, 2009
69. Rosen D, Berrios-Thomas S, Engel RJ: Increasing self-knowledge: utilizing tele-coaching for patients with congestive heart failure. *Soc Work Health Care* 55:711–719, 2016
70. Con D, De Cruz P: Mobile phone apps for inflammatory bowel disease self-management: a systematic assessment of content and tools. *JMIR Mhealth Uhealth* 4:e13, 2016
71. Ho K: Health-e-apps: a project to encourage effective use of mobile health applications. *BC Med J* 55:458–460, 2013