How to Overcome Barriers and Establish a Successful Home HD Program

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Summary

Home hemodialysis (HD) is an underused dialysis modality in the United States, even though it provides an efficient and probably cost-effective way to provide more frequent or longer dialysis. With the advent of newer home HD systems that are easier for patients to learn, use, and maintain, patient and provider interest in home HD is increasing. Although barriers for providers are similar to those for peritoneal dialysis, home HD requires more extensive patient training, nursing education, and infrastructure support in order to maintain a successful program. In addition, because many physicians and patients do not have experience with home HD, reluctance to start home HD programs is widespread. This in-depth review describes barriers to home HD, focusing on patients, individual physicians and practices, and dialysis facilities, and offers suggestions for how to overcome these barriers and establish a successful home HD program.

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Introduction

Home hemodialysis (HD) is a kidney replacement therapy that can provide safe, high-quality treatment and empowers patients to take charge of their dialysis therapy (1). In addition, the therapy is versatile: It can be offered thrice weekly, as short daily session (≥4 days per week), or nocturnally (≥3 nights per week). Observational data suggest that home therapies may improve patient survival and quality of life and reduce uremic complications compared with thrice-weekly in-center HD (1–17). Herein, we review barriers to home HD and provide strategies to build a successful home HD program. This paper complements the recently published document by the International Society for Peritoneal Dialysis; in contrast to this previous publication, this review identifies steps a physician or practice can take to overcome the barriers to home HD in the current regulatory and reimbursement framework (18).

Trends in Home HD Use around the World

Home HD began in 1964 in Boston, Massachusetts; Seattle, Washington; and London, United Kingdom, as a means of treating more ESRD patients in an environment of limited resources (19–22). Despite the demonstrable benefits, use of home HD declined steadily from 36% of all patients in 1973 to 0.6% in 2002 (23). With increased interest in more frequent or longer HD treatments, home HD use in the United States has begun to increase (24). By 2009, 4511 patients (1%) were being treated with home HD (23), and preliminary 2012 estimates suggest the number of patients now exceeds 6000.

Despite increased enthusiasm for HD, there remain considerable barriers from the perspectives of patients, physicians, and facilities (Figure 1).

Benefits of Home HD

Potential for Greater Dialysis Delivery

Overnight home HD, performed 6–8 hours thrice weekly, was common in the 1960s and 1970s; however, thrice-weekly diurnal (daily) treatment soon became the most common form of home HD, with sessions typically longer than the current 3–4 hours. Over the last 40 years, several observational studies have shown that compared with patients undergoing in-center HD, patients treated with thrice-weekly home HD have lower risk for death, improved BP control, higher health-related quality of life, and greater opportunity for rehabilitation and employment; in addition, home HD provides greater cost-effectiveness (25–31).

Recently, interest in both short-diurnal HD performed more frequently than thrice weekly and long, overnight, frequent HD has grown. Compared with in-center HD, these treatments deliver greater small solute, phosphorus, and β_2-microglobulin clearances and better volume control, potentially resulting in regression of left ventricular hypertrophy, improved nutrition, and enhanced quality of life (32–37). In addition, considerable evidence suggests that more frequent treatments are best delivered at home (25,38–44). Moreover, more than a quarter of patients in the recent Frequent Hemodialysis Network (FHN) daily trial dropped out of the study because of scheduling conflicts or inability to come to the dialysis unit six times per week (45). Thus, short-diurnal HD is associated with improved outcomes and is easier to deliver at home compared with in-center HD.

As an alternative to more frequent therapies, long alternate-night home HD is attractive; it eliminates the weekly 2-day gap between dialysis sessions at weekends that can adversely affect patient outcomes (46). Although

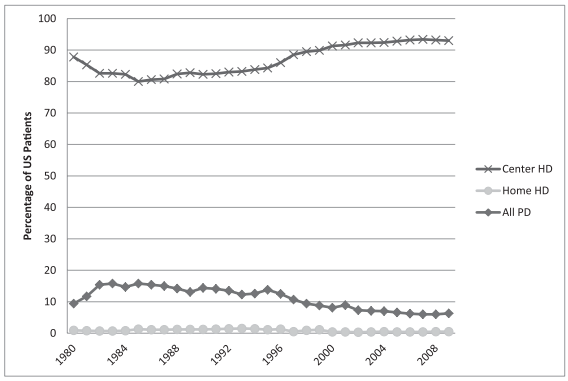

Figure 1. | **Annual incident ESRD patients by modality from 1980 to 2009 from the U.S. Renal Data System.** HD, hemodialysis; PD, peritoneal dialysis.

it requires a larger ultrafiltration volume per session than nocturnal HD six times a week or short-diurnal home HD, long alternate-night HD produces relatively good phosphate control. However, depending on the dialysis system, it may not eliminate the need for phosphate binders (47).

Possibilities for Better Patient Survival

No adequately powered randomized, controlled clinical trials have compared the mortality rates between home HD regimens and conventional thrice-weekly in-center HD. The FHN trial randomly assigned participants to short daily (six times a week) in-center HD or thrice-weekly in-center HD and examined a composite endpoint of 1-year mortality and change in left ventricular mass. A significant benefit occurred with more frequent therapy (hazard ratio [HR] for death or decrease in left ventricular mass, 0.61; 95% confidence interval [CI], 0.46–0.82) (43). It is important to note that this clinical trial used conventional HD machines and did not examine whether home HD will provide benefits similar to those of in-center HD or low-flow HD systems (which are increasingly used for home HD). Several observational studies have reported survival with short daily HD, the largest of which showed a 50% lower death risk and survival rates similar to those achieved with deceased-donor transplantation (32,48).

Two randomized trials have compared nocturnal home HD with thrice-weekly HD treatments. Culleton *et al.* randomly assigned 52 patients to six-times-a-week nocturnal home HD or standard thrice-weekly in-center HD. Over 6 months, nocturnal home HD was associated with greater reduction of left ventricular mass (net difference, −15.3 g; P=0.04) (37). The more recent FHN trial randomly assigned 87 patients to six-times-a-week or thrice-weekly home nocturnal HD or conventional home HD and showed no difference between groups in the composite endpoint of 1-year mortality and change in left ventricular mass, but it was inadequately powered for survival alone (49).

Several observational studies have also examined the survival of patients treated with nocturnal home HD. One of the best-matched cohort studies looked at patient and technique survival among 247 Canadian patients treated with nocturnal home HD. The unadjusted 1- and 5-year adverse event-free survival rates were 95% and 80%, respectively, and the technique survival rates at 1 and 5 years were 98% and 95% (28,31). Additionally, according to the International Quotidian Dialysis Registry compared with the Dialysis Outcomes and Practice Patterns Study, patients receiving intensive (>5.5 hours per day or night) HD had a 45% better survival (HR, 0.55; 95% CI, 0.34–0.87) than in-center HD patients after adjustment (28).

Health-Related Quality of Life and Home HD

Determining whether changes in health-related quality of life (HRQOL) was associated with home HD result from dialysis regimens themselves or selection of home as the treatment setting is challenging, particularly given the impossibility of blinding participants to their treatment modality. In this context, one study demonstrated no significant difference in HRQOL of patients treated with nocturnal HD or peritoneal dialysis (PD), both of which were performed at home (50). Nevertheless, the short-daily in-center FHN trial suggests that selected HRQOL measures, such as the physical health composite score of the Short-Form 36, improved significantly, even though objective measurements of exercise tolerance did not improve (51). Of note, however, sustained improvements in patient-reported outcomes have been demonstrated in a variety of measures, including sleep, restless legs, depressive symptoms, time to recovery after an HD session, and almost all domains on the Short-Form 36 (34,35,52). These improvements need to be balanced by the burden of the therapy and effect on the caregiver. Although some studies have suggested a low technique failure rate, others suggested nearly 20% transfer back to in-center HD (35). The reasons for these discrepant observations require further investigation (53).

Patient Independence, Rehabilitation, and Employment Potential

It was recognized many years ago that many patients undergoing dialysis in a center easily became dependent on the staff and were eventually reduced to a state of "learned helplessness" (54). Accordingly, advantages of any home dialysis therapy include encouraging patient independence, responsibility, and confidence; allowing them to set their own schedules; increasing comfort and convenience; and reducing the risk for infection (17). In addition, in a Finnish study, home HD allowed for continued employment compared with in-center HD (prevalence rate ratio, 2.14; 95% CI, 1.68–2.74) (55) Although similar data from the United States comparing home dialysis with in-center HD found PD to be associated with increased employment at initiation of dialysis, data were lacking for home HD (56).

Greater Ability to Travel

Recent development of smaller, more portable home HD systems makes travel easier than before, and airlines transport a dialysis system at no additional charge because it is a medical device (57,58). Accordingly, patients may require prior arrangement with the dialysis system companies to facilitate delivery of dialysate before travel, and travel may be limited to certain geographic areas.

Barriers to Home HD

A Silent Barrier: Lack of Patient Education

When asked, most patients would like to choose their own dialysis modality (59). However, although informed

choice is emphasized, comprehensive predialysis education is often inadequate. Historically, up to 88% of patients in the United States reported being unaware that home HD was an option for treatment of ESRD (60). Lack of modality education typically leads to in-center HD as the default dialysis modality, particularly for late-referred patients (61,62). In addition, the quality of education, extent of patient involvement, patient comprehension, and amount of time spent discussing treatment options are important determinants of patient selection of home dialysis (60,61,63,64).

Patient Perceptions

Patients' obstacles to adopting home dialysis include a lack of interest, fear of change, lack of self-confidence, concerns of substandard care, and belief that patients should not be involved in self-care (Table 1) (64–66). Some of these fears may be overcome when caregivers are available in the home, although patients must be encouraged to undertake as many of the tasks of home HD as they are able. However, patients' perception of burden on caregivers, especially family members (67), may influence their perception of home HD (65,68). Dialysis support either through unpaid family members or paid helpers may help mitigate barriers to home HD. Furthermore, there are treatment-specific barriers to home HD, such as fear of self-cannulation, needle disconnect, or a catastrophic event (65). Nurse-directed cannulation training and home monitoring may help patients overcome these fears (69,70).

Physician Barriers

Evidence suggests that many nephrologists contribute to the inadequacy of patient education about home dialysis, in part because of their own educational gaps regarding home therapies (60,71,72). Furthermore, physicians may rely on an outdated paradigm in discussing treatment modalities, where, in the absence of an available transplant, the default may be "PD or HD." Golper and Schreiber have articulated a different paradigm wherein the PD-versus-HD decision should be the fourth decision after the patient has already considered kidney replacement therapy versus maximum conservative care, pre-emptive transplantation versus dialysis, and home versus in-center dialysis (73).

Mechanical Complexity

The complexity of conventional HD system—including set up and take off; training time; heat and chemical disinfection; water requirements for generation of dialysate; and space for machine, water system, and supplies at home—may dissuade some patients from considering home HD (65,70,71). The only conventional HD machine approved by the U.S. Food and Drug Administration (FDA) for use at home is the Fresenius 2008 K@Home.

The NxStage machine, approved by the FDA in 2005, is now the most widely used machine for home HD in the United States; it blends the concept of a PD cycler with the home HD machine to create a portable system and has a short set-up time (drop-in disposable cartridge), automated prime and rinse back, wipe-down disinfect, and the use of dialysate bags for travel (74). At least four additional systems are in development: a second-generation AKSYS machine by DEKA Research in partnership with Baxter Healthcare, a machine using sorbent technology by Fresenius Medical Care, a portable machine by the University of Oregon and Hemodialysis Plus, and another portable machine by Quanta SelfCare Plus. Additionally, a wearable artificial kidney is also being tested at several institutions in the United States (75). These easier-to-use systems would help patients surmount the barrier associated with machine complexity.

Table 1. Patient perspectives on home dialysis

Perspective	General Attitude	Treatment-Specific Attitude
Favors selection of home dialysis	Greater freedom	Freedom of time and diet
	Better lifestyle	Accommodates desire to work
	More control	Reduced travel to dialysis unit
	Increased involvement in care	Cost-effective modality
	Reduced dependence	
Favors selection of in-center HD	Lack of self efficacy	Therapy will interfere with home life
	Fear of substandard care and lack of supervision	Fear of machine
	Fear of social isolation	Fear of a catastrophic event
	Lack of motivation	Fear of self-cannulation (NHD)
	Fear of change	Fear of needle disconnect (NHD)
	Belief that patient should not be involved in care	Intradialytic symptoms during HD
	Family or patient disinterest	Therapy is time-consuming
	Fear of burdening caregivers	Negative effect of therapy on sleep
	Lack of social support	Unable to manage at home because of physical limitations
		Perceived lack of home space

NHD, nocturnal hemodialysis. Data obtained from references 96 and 97, Cafazzo *et al.* 2009; Zhang *et al.* 2010.

Home Water Treatment

Conventional water treatment systems use standard, portable, reverse osmosis systems, but these are limited by

the need for large amounts of water; dialysis facilities generally do not compensate patients for the water, and municipalities do not discount the water use. To overcome this, many newer home HD systems can include the possibility of using premixed sterile dialysate bags, production of ultra-pure dialysate using reverse osmosis and deionization in small tanks, or sorbent regeneration of dialysate.

Cost of Home HD

Many studies worldwide have shown that overall home HD costs are 20%–50% less than those of in-center HD (76–83). The greatest reason for this cost differential is staffing and facility overhead. There are also expense reductions from the potential for decreased hospitalizations and reduced use of medications (antihypertensive agents and phosphate binders). Travel to and from the dialysis facility also creates lost time and financial costs that are not experienced with home dialysis. On the other hand, the cost of setting up the home for HD, equipment, and training add expense to home HD. As the frequency of treatments per week rises, the cost reduction compared with conventional in-center HD decreases. Yet, overall, daily home HD is still less costly than in-center HD (81,83).

In the United States, the potential for cost savings for the provider with home dialysis is largely influenced by policies of the Centers for Medicare & Medicaid Services. The incentives to providers, patients, and physicians are summarized in Table 2. The new prospective payment system, implemented in 2011, provides a single composite rate for each session that now includes all ESRD-related parenteral medications and their oral equivalents. Of note, the base payment for home dialysis remains same as that for in-center HD, potentially providing an incentive for use of home dialysis.

However, payment to providers for home HD training remains inadequate. In August 1983, payment of $20 per training day was introduced. This certainly did not cover the actual cost of home HD training, and, with thrice-weekly home HD, it took the facility 12–18 months to recover the training costs (80). With the changes implemented in 2011, facilities receive 51% higher payments during the first 120 days whether the patients undergo in-center or at-home dialysis. This payment is expected to cover the costs of training a patient who chooses home dialysis and completes the training during this time. Thereafter, there is a $33.44 add-on payment per day of home HD patient training for up to 25 sessions. Depending on the training program, the home training add-on now covers 55%–70% of the actual costs of training; however, this incentive is somewhat offset by the increased funding for both in-center and home HD patients on days 0–120.

Table 2. Summary of financial incentives in place in 2012 for home dialysis

Person/Provider	Incentives/Advantages
For dialysis provider	Same per-treatment reimbursement as in-center HD
	Receive additional reimbursement for providing home training to patients after 120 days on dialysis
	Payment retroactive to first day of the month of initiation of home dialysis
	Ability to use fewer of the costly medications
	Potential to expand census of some centers with trivial or no increase in infrastructure (*e.g.*, can unload full HD census by transfer to home therapy)
For patient	Lower transportation costs
	Less time away from work
	Payment to providers retroactive to first day of the month of initiation for Medicare-eligible patients not covered at time of start of dialysis
	Lower medication costs (oral vitamin D covered in prospective payment system bundle)
For physician	Reimbursement for training home dialysis patients
	Same monthly payment for one visit as received for 2–3 visits for in-center HD patients
	Can receive payment if patient misses appointment for face-to-face visit (with appropriate documentation)
	Payment to physicians retroactive to first day of the month of initiation for Medicare-eligible patients not covered at time of start of dialysis
	Increase geographic area of patient referrals (can provide dialysis care for patients who live far away)

HD, hemodialysis.

Organization and Structure of Home HD Program

Few studies have examined the optimal organization and structure of a home HD program. In many ways, the organization and structure of PD programs could be a model for home HD. Home HD programs should include the following:

Adequate Patient Education

During routine predialysis education, it is essential to objectively discuss with patients the potential benefits and problems of home HD and the various regimens and machines. Recent data suggest that use of iterative CKD education that engages the patient and family and involves patients treated with different dialysis therapies can be successful at increasing the use of home dialysis (84–86). Moreover, even in patients with unplanned acute-start dialysis, patient education has been associated with successful transition to home dialysis (87). Thus, education is a critical element to the successful development of a home HD program. In addition to training program staff, all facility nurses, dietitians, and social workers must be educated about the potential benefits and burdens of each modality and encouraged to talk about treatment options with patients. Nephrologists should also encourage current home HD patients and their partners to be actively involved in the pre-ESRD classes.

One of the most important selection criteria is that after appropriate education the patient desires to do home HD.

Age, education, sex, housing, water source, and comorbid conditions should be evaluated but are not exclusion criteria. Patients who would otherwise prefer to perform home HD may be initially resistant because of fear of operating the machine, self-cannulation, or a life-threatening disaster (65,70). Accordingly, the principal goal of the education program should be to reassure patients and mitigate their concerns. Methods to overcome these barriers involve teaching patients self-cannulation before home training while in the dialysis center, using a central venous catheter as initial access or while an arteriovenous fistula is maturing, providing opportunities to practice setting up the machine before training, and talking to successful home HD patients.

Adequate Physician Training

It is equally necessary for nephrologists to understand the basic principles of home HD and how it differs from in-center HD. Building basic training in home therapies into nephrology training programs has proved challenging because at present many do not have home HD programs and, in centers that do, patients are seen less frequently than those who undergo in-center HD.

Adequate Nurse Training

It is imperative that patients be trained by nurses who are dedicated to home dialysis to ensure the training is comprehensive and accurate. Simply pulling a nurse from an in-center HD program to conduct the training without providing sufficient home HD training is inadequate. Proper patient communication and education require skills, compassion, and empathy to understand the unique needs of home dialysis patients. Nurses must be trained in best practices for managing home HD programs in order to adequately train patients, such that patients feel secure performing dialysis at home (85).

Adequate Staffing

Although several nephrologists in a program may provide care to home HD patients, one or more should be responsible for addressing the basic practices of the program and championing the therapy. The entire dialysis staff, including nurses, social workers, dietitians, and physicians, must be able to provide appropriate support for the patients and their caregivers.

Adequate Patient Census

It is neither feasible nor necessary for each physician practice to have a separate home HD training program. Furthermore, lessons from PD indicate that smaller programs have higher technique failure rates (88). Thus, the appropriate approach is to develop centralized training facilities with enough nursing expertise and infrastructure to support a large growing home program.

Appropriate Continuous Quality Improvement Programs

Quality improvement programs are necessary to prospectively monitor outcomes and modify treatment algorithms. These programs should adequately address the needs of home HD patients and not simply extrapolate from those used for PD and in-center HD. These include, but are not limited to, vascular access issues, infections, equipment problems, water treatment, and adequacy of dialysis.

Best Demonstrated Practices for Establishment of a Successful Home HD Program

Selection of Dialysis Machine

Machine choice depends on the facility and the treatment regimen. Fresenius K@Home can provide thrice-weekly or alternate-day therapy or daily diurnal or nocturnal HD. The NxStage System can provide more frequent short-daily or nocturnal HD (Table 3).

Table 3. Comparison of possible dialysis prescription and advantages for short-daily, nocturnal, or extended-daily hemodialysis

Treatment Variable	Short-Daily HD		Nocturnal or Extended-Daily HD	
	NxStage	Fresenius K@Home	NxStage	Fresenius K@Home
Frequency (d/wk)	5–6	5–6	4–6	4–6
Time (hr)	2.5–4.0	2.5–4.0	5.0–8.0	5.0–8.0
Blood flow (ml/min)	300–450	300–450	200–350	200–350
Dialysate flow (ml/min)	83–200	500–800	63–200	200–300
Calcium (mEq/dl)	3.0	3.0–3.5	3.0	3.0–3.5
Dialysate base[a]	Lactate, 40–45 mEq/L	Bicarbonate, 28–35 mEq/L	Lactate, 40–45 mEq/L	Bicarbonate, 28–35 mEq/L
Potassium (mEq/L)	1.0 or 2.0	2.0	1.0 or 2.0	2.0
Dialysate per session (L)	20–30	75–192	30–60	60–144
Maximum ultrafiltration	Pull to target	Pull to target	400–600 ml/hr	400–600 ml/hr
Advantages	Easy-to-use cartridge system No house alterations No 2-day gap	No 2-day gap	No 2-day gap No house alterations	Better phosphorus control than low-volume dialysate

HD, hemodialysis.
[a]Comparison values are approximate.

Prescribing Dialysis Regimen

Although many aspects of home HD are similar to in-center HD, prescriptions differ by dialysis type and the machine (Table 3). Because the 2008 K@Home uses higher dialysate flow, there is greater small-solute removal; increasing the dialysate volume used during a NxStage treatment session can achieve similar clearances (36).

Dialysis Access

Successful home HD requires a reliable vascular access. Arteriovenous fistulas are the access of choice, although there has been concern that more frequent dialysis may lead to increased risk for access failure. Some observational data have shown that more frequent HD was not associated with increased risk for access-related hospitalizations (89), and the FHN daily trial found no differences in access-associated mortality or interventions. However, in the FHN trial, patients more frequently undergoing in-center HD were more likely to have vascular access–related interventions (HR, 1.71; 95% CI, 1.08–2.73) (32), whereas there was a trend toward increased risk for access failure (HR, 1.88; 95% CI, 0.97–3.64; P=0.06) among nocturnal HD patients compared with conventional home HD patients (37). In addition, observational studies from Australia found a three-fold greater risk for septic events for nocturnal HD patients (HR, 3.0; 95% CI, 1.04–8.66) (90). Thus, there is the potential for increased risk for adverse access events with nocturnal HD, and strategies to minimize this risk should be incorporated during training and follow-up.

In addition, self-cannulation is difficult for some patients and must be learned in a timely manner. Self-cannulation can begin in-center or can be taught over time as the fistula matures. Patient acceptance of self-cannulation can be enhanced with use of the buttonhole technique, which uses the same needle entry point with the same entry angle. Buttonholes have been associated with 93% shorter bleeding time, 81% less pain, and 80% improved look of the fistula compared with rope ladder technique (91). However, there is a potential for higher infection risk (90). Hence, meticulous attention is needed to reduce the potential for increased infection with the use of the buttonhole technique (92).

Training

Patient safety must be discussed at length during home HD training; as with all HD therapies, complications can occur and are offset by adequate patient training (93). Short frequent (daily) HD generally has lower ultrafiltration volumes per session and is better tolerated than thrice-weekly sessions. The safety of frequent nocturnal HD is enhanced by limiting the maximum ultrafiltration to 400–600 ml/hr, using blood flow rates of 200–350 ml/min, and lower dialysate flow than is used with thrice-weekly session. In addition, some of the equipment used in home HD is less complex than for in-center HD and thus is less likely to be associated with technical errors. Nonetheless, the supervising physician cannot take the risks of self-HD lightly. In its approval of the home HD systems, the FDA mandated that a partner must be trained along with the patient; despite this, many patients voluntarily dialyze alone. One role that must be categorically perfected is emergency care for catastrophic events, such as hemorrhage or loss of consciousness. Managing power outages with return of blood, prevention and treatment of suspected air emboli, the treatment of hypotension, and how to anchor needles and catheters to prevent dislodges and disconnects should also be mastered. Clear lines of communication and emergency procedures should also be established.

There is a paucity of published literature validating any specific training program. Table 4 describes the training focus and weekly objectives of a typical training program. During training, the patient should also receive technical education on the operation and maintenance of the water treatment system.

Remote Monitoring of Patients and Patient Safety

The long-term experience in Seattle, Washington; Toronto, Ontario, Canada; and Lynchburg, Virginia, have shown that remote monitoring is not a necessity (94). However, as home HD expands into centers that have less experience or are geographically isolated, monitoring may become necessary. It is also possible to offer this safety component for certain patients for physiologic or psychological reasons, especially nocturnal HD patients. Less complete monitoring, such as enuresis devices to detect blood leaks, are popular, reasonably

Table 4. Suggested training for home hemodialysis week by week.

Week of Training	Training Focus	Objectives
Week 1 and 2	Operation of the dialysis facility Learning new vocabulary Hand washing Self-assessment (BP, weight) Introduction to the manual of dialysis Access care	Understanding HD Self-assessment
Week 3	Equipment preparation Disconnect procedure Alarms management Self-cannulation Learner doing tasks under the supervision of the trainer	Setting up the HD machine without the manual
Week 4	Alarms management Complications management Meeting with the technician for introduction to water management Recirculation procedure	Self-cannulation (may be longer) Management of complications and alarms
Week 5	Learner doing dialysis alone with the nurse being away	Achieving total independent self-care

HD, hemodialysis.

inexpensive, and reliable (47). Other available devices include the Redsense monitor to detect needle disconnection. Accordingly, patient safety at home and requirements for a partner or additional person to be present during the actual dialysis is recommended but cannot be universally enforced. In addition, some units require that nursing staff be present at the first dialysis run at home, although this practice is not the standard of care for all facilities.

Other Technical Considerations

During assessment for home HD, technical staff must visit the patient's home to assess the water source, electrical access points, and layout of the residence. The type of water (hard versus soft) may affect the choice of water treatment. Electric fuse panel assessment and modifications may be necessary to avoid surge and power outage during HD treatment, especially if a conventional dialysis machine is used. The type of housing (apartment, house, or cottage) and ownership should also be assessed.

Post-Training Expectations

After obtaining weekly milestones and passing all tests associated with training, patients are ready to go home for dialysis. As the "graduation date" from the program nears, supplies for home need to be ordered and preparations for taking the machine home need to be discussed. Expectations regarding staying at home are also reviewed, and patient goals and adherence should be agreed upon to avoid potential conflicts and misunderstandings (Table 5). Communication with the dialysis unit, nurses, and physicians should be stressed as part of the teaching.

The first 3 months of the patient dialyzing at home are the most critical and will affect whether the patient will remain at home. Sending a dialysis facility staff member home to watch the first set-up or dialysis may be helpful, and, if possible, weekly visits for the first month and every other week for the second month to the home training center by the patient are useful. Having the patient call the nurse both before starting and after completing the treatment for the first 1–2 weeks helps reassure and empower the patient. Having on-call nursing support 24 hours a day, 7 days a week is also crucial.

Home HD clinics function similarly to PD clinics. Patients can receive intravenous iron, have their accesses evaluated, and participate in additional educational sessions, as appropriate.

Table 5. Goals to be reviewed with patient upon completion of home hemodialysis training

1. Perform HD treatment per physician's prescription
2. Contact the facility and/or the manufacturer with machine problems
3. Draw blood to be sent for routine testing, including pre- and post-treatment samples to calculate Kt/V_{urea}
4. Turn in home treatment logs regularly as required
5. Agree to visit nephrologist or attend home HD clinic at least once every 2 months
6. Order supplies on time

HD, hemodialysis.

Patient Burnout and Return to Center

Patient and family burnout can occur early or late after initiating home HD. Risk factors for returning to in-center dialysis include older age and unrelated helper; race/ethnicity and underlying cause of ESRD are not associated with return to center dialysis (95). Families, spouses, and significant others may not realize all that is involved with home HD, and sometimes patients want to compartmentalize dialysis and keep the home area a "medical free" zone. Occasionally there may be family conflict or abuse. Patients may show burnout through not submitting their dialysis logs or drawing blood for laboratory testing on time, more frequent hospitalizations, or lack of communication with the center. Depression should also be considered and addressed as needed. Respite care can be considered for patients and helpers for whom a break from dialyzing at home may be needed.

Conclusions

Home HD has the potential to allow patients to enjoy increased freedom, quality of life, greater ability to travel, and tangible improvements in several domains of medical outcomes. Increased physician and patient education can eliminate barriers to home HD and increase its use.

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C.C. serves as a member of the scientific advisory board for Baxter Healthcare. C.B. is a consultant to DEKA Research and Development Corporation. R.L. serves as a member of the scientific advisory board for Fresenius Medical Care. T.G. conducts consultant activity for Baxter, Fresenius, DaVita, Takeda-Affymax, and Q Source. F.F. serves as a member of the scientific advisory board for NxStage and conducts consultant activity for Baxter Healthcare. R.S. is an employee of the American Society of Nephrology. R.M. has received grant support and/or honoraria from Baxter Healthcare, DaVita, Mitsubishi, Shire, Takeda, and Vifor.

References

1. Suri RS, Nesrallah GE, Mainra R, Garg AX, Lindsay RM, Greene T, Daugirdas JT: Daily hemodialysis: A systematic review. *Clin J Am Soc Nephrol* 1: 33–42, 2006
2. Plantinga LC, Fink NE, Harrington-Levey R, Finkelstein FO, Hebah N, Powe NR, Jaar BG: Association of social support with outcomes in incident dialysis patients. *Clin J Am Soc Nephrol* 5: 1480–1488, 2010
3. Arkouche W, Traeger J, Delawari E, Sibaï-Galland R, Abdullah E, Galland R, Leitienne P, Fouque D, Laville M: Twenty-five years of experience with out-center hemodialysis. *Kidney Int* 56: 2269–2275, 1999
4. Scribner BH: A personalized history of chronic hemodialysis. *Am J Kidney Dis* 16: 511–519, 1990
5. Delano BG: Home hemodialysis offers excellent survival. *Adv Ren Replace Ther* 3: 106–111, 1996
6. Delano BG, Friedman EA: Correlates of decade-long technique survival on home hemodialysis. *ASAIO Trans* 36: M337–M339, 1990
7. Mailloux LU, Kapikian N, Napolitano B, Mossey RT, Bellucci AG, Wilkes BM, Vernace MA, Miller IJ: Home hemodialysis: Patient outcomes during a 24-year period of time from 1970 through 1993. *Adv Ren Replace Ther* 3: 112–119, 1996
8. McGregor D, Buttimore A, Robson R, Little P, Morton J, Lynn K: Thirty years of universal home dialysis in Christchurch. *N Z Med J* 113: 27–29, 2000
9. Roberts JL: Analysis and outcome of 1063 patients trained for home hemodialysis. *Kidney Int* 9: 363–374, 1976
10. 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
11. Finkelstein FO, Finkelstein SH, Wuerth D, Shirani S, Troidle L: Effects of home hemodialysis on health-related quality of life measures. *Semin Dial* 20: 265–268, 2007
12. Oberley ET, Schatell DR: Home hemodialysis: Survival, quality of life, and rehabilitation. *Adv Ren Replace Ther* 3: 147–153, 1996
13. Honkanen EO, Rauta VM: What happened in Finland to increase home hemodialysis? *Hemodial Int* 12[Suppl 1]: S11–S15, 2008
14. McGregor DO, Buttimore AL, Lynn KL: Home hemodialysis: Excellent survival at less cost, but still underutilized. *Kidney Int* 57: 2654–2655, 2000
15. Mowatt G, Vale L, MacLeod A: Systematic review of the effectiveness of home versus hospital or satellite unit hemodialysis for people with end-stage renal failure. *Int J Technol Assess Health Care* 20: 258–268, 2004
16. Winkelmayer WC, Weinstein MC, Mittleman MA, Glynn RJ, Pliskin JS: Health economic evaluations: The special case of end-stage renal disease treatment. *Med Decis Making* 22: 417–430, 2002
17. Finkelstein FO, Abu-Aisha H, Najafi I, Lo WK, Abraham G, Pecoits-Filho R, Süleymanlar G: Peritoneal dialysis in the developing world: Recommendations from a symposium at the ISPD meeting 2008. *Perit Dial Int* 29: 618–622, 2009
18. Golper TA, Saxena AB, Piraino B, Teitelbaum I, Burkart J, Finkelstein FO, Abu-Alfa A: Systematic barriers to the effective delivery of home dialysis in the United States: A report from the Public Policy/Advocacy Committee of the North American Chapter of the International Society for Peritoneal Dialysis. *Am J Kidney Dis* 58: 879–885, 2011
19. Curtis FKCJ, Cole JJ, Tyler LL, Scribner BH: Hemodialysis in the home. *Trans Am Soc Artif Intern Organs* 11: 7–10, 1965
20. Eschbach JW Jr, Wilson WE Jr, Peoples RW, Wakefield AW, Babb AL, Scribner BH: Unattended overnight home hemodialysis. *Trans Am Soc Artif Intern Organs* 12: 346–356, 1966
21. Hampers CL, Merrill JP: Hemodialysis in the home—13 months' experience. *Ann Intern Med* 64: 276–283, 1966
22. Merrill JP: Hemodialysis in the home. *JAMA* 206: 124, 1968
23. U.S. Renal Data System: USRDS 2011 Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the United States, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2011
24. Agar JW, Hawley CM, George CR, Mathew TH, McDonald SP, Kerr PG: Home haemodialysis in Australia - is the wheel turning full circle? *Med J Aust* 192: 403–406, 2010
25. Blagg CR: Home haemodialysis: 'Home, home, sweet, sweet home!' *Nephrology (Carlton)* 10: 206–214, 2005
26. Kjellstrand C, Buoncristiani U, Ting G, Traeger J, Piccoli GB, Sibai-Galland R, Young BA, Blagg CR: Survival with short-daily hemodialysis: Association of time, site, and dose of dialysis. *Hemodial Int* 14: 464–470, 2010
27. Kjellstrand CM, Buoncristiani U, Ting G, Traeger J, Piccoli GB, Sibai-Galland R, Young BA, Blagg CR: Short daily haemodialysis: Survival in 415 patients treated for 1006 patient-years. *Nephrol Dial Transplant* 23: 3283–3289, 2008
28. Nesrallah GE, Lindsay RM, Cuerden MS, Garg AX, Port F, Austin PC, Moist LM, Pierratos A, Chan CT, Zimmerman D, Lockridge RS, Couchoud C, Chazot C, Ofsthun N, Levin A, Copland M, Courtney M, Steele A, McFarlane PA, Geary DF, Pauly RP, Komenda P, Suri RS: Intensive hemodialysis associates with improved survival compared with conventional hemodialysis. *J Am Soc Nephrol* 23: 696–705, 2012
29. Pauly RP, Asad RA, Hanley JA, Pierratos A, Zaltzman J, Chery A, Chan CT: Long-term clinical outcomes of nocturnal hemodialysis patients compared with conventional hemodialysis patients post-renal transplantation. *Clin Transplant* 23: 47–55, 2009
30. Pauly RP, Gill JS, Rose CL, Asad RA, Chery A, Pierratos A, Chan CT: Survival among nocturnal home haemodialysis patients compared to kidney transplant recipients. *Nephrol Dial Transplant* 24: 2915–2919, 2009
31. Pauly RP, Maximova K, Coppens J, Asad RA, Pierratos A, Komenda P, Copland M, Nesrallah GE, Levin A, Chery A, Chan CT; CAN-SLEEP Collaborative Group: Patient and technique survival among a Canadian multicenter nocturnal home hemodialysis cohort. *Clin J Am Soc Nephrol* 5: 1815–1820, 2010
32. Chertow GM, Levin NW, Beck GJ, Depner TA, Eggers PW, Gassman JJ, Gorodetskaya I, Greene T, James S, Larive B, Lindsay RM, Mehta RL, Miller B, Ornt DB, Rajagopalan S, Rastogi A, Rocco MV, Schiller B, Sergeyeva O, Schulman G, Ting GO, Unruh ML, Star RA, Kliger AS; FHN Trial Group: In-center hemodialysis six times per week versus three times per week. *N Engl J Med* 363: 2287–2300, 2010
33. Greene T, Daugirdas JT, Depner TA, Gotch F, Kuhlman M; Frequent Hemodialysis Network Study GroupNational Institute of Diabetes and Digestive and Kidney DiseasesNational Institutes of Health: Solute clearances and fluid removal in the frequent hemodialysis network trials. *Am J Kidney Dis* 53: 835–844, 2009
34. Jaber BL, Lee Y, Collins AJ, Hull AR, Kraus MA, McCarthy J, Miller BW, Spry L, Finkelstein FO; FREEDOM Study Group: Effect of daily hemodialysis on depressive symptoms and postdialysis recovery time: Interim report from the FREEDOM (Following Rehabilitation, Economics and Everyday-Dialysis Outcome Measurements) Study. *Am J Kidney Dis* 56: 531–539, 2010
35. Jaber BL, Schiller B, Burkart JM, Daoui R, Kraus MA, Lee Y, Miller BW, Teitelbaum I, Williams AW, Finkelstein FO; FREEDOM Study Group: Impact of short daily hemodialysis on restless legs symptoms and sleep disturbances. *Clin J Am Soc Nephrol* 6: 1049–1056, 2011
36. Kohn OF, Coe FL, Ing TS: Solute kinetics with short-daily home hemodialysis using slow dialysate flow rate. *Hemodial Int* 14: 39–46, 2010
37. Rocco MV, Lockridge RS Jr, Beck GJ, Eggers PW, Gassman JJ, Greene T, Larive B, Chan CT, Chertow GM, Copland M, Hoy CD, Lindsay RM, Levin NW, Ornt DB, Pierratos A, Pipkin MF, Rajagopalan S, Stokes JB, Unruh ML, Star RA, Kliger AS, Kliger A, Eggers P, Briggs J, Hostetter T, Narva A, Star R, Augustine B, Mohr P, Beck G, Fu Z, Gassman J, Greene T, Daugirdas J, Hunsicker L, Larive B, Li M, Mackrell J, Wiggins K, Sherer S, Weiss B, Rajagopalan S, Sanz J, Dellagrottaglie S, Kariisa M, Tran T, West J, Unruh M, Keene R, Schlarb J, Chan C, McGrath-Chong M, Frome R, Higgins H, Ke S, Mandaci O, Owens C, Snell C, Eknoyan G, Appel L, Cheung A, Derse A, Kramer C, Geller N, Grimm R, Henderson L, Prichard S, Roecker E, Rocco M, Miller B, Riley J, Schuessler R, Lockridge R, Pipkin M, Peterson C, Hoy C, Fensterer A, Steigerwald D, Stokes J, Somers D, Hilkin A, Lilli K, Wallace W, Franzwa B, Waterman E, Chan C, McGrath-Chong M, Copland M, Levin A, Sioson L, Cabezon E, Kwan S, Roger D, Lindsay R, Suri R, Champagne J, Bullas R, Garg A, Mazzorato A, Spanner E, Rocco M, Burkart J, Moossavi S, Mauck V, Kaufman T,

Pierratos A, Chan W, Regozo K, Kwok S; Frequent Hemodialysis Network (FHN) Trial Group: The effects of frequent nocturnal home hemodialysis: The Frequent Hemodialysis Network Nocturnal Trial. *Kidney Int* 80: 1080–1091, 2011
38. Chan CT, Floras JS, Miller JA, Richardson RM, Pierratos A: Regression of left ventricular hypertrophy after conversion to nocturnal hemodialysis. *Kidney Int* 61: 2235–2239, 2002
39. Chan CT, Harvey PJ, Picton P, Pierratos A, Miller JA, Floras JS: Short-term blood pressure, noradrenergic, and vascular effects of nocturnal home hemodialysis. *Hypertension* 42: 925–931, 2003
40. Chan CT, Notarius CF, Merlocco AC, Floras JS: Improvement in exercise duration and capacity after conversion to nocturnal home haemodialysis. *Nephrol Dial Transplant* 22: 3285–3291, 2007
41. Chan CT, Shen XS, Picton P, Floras J: Nocturnal home hemodialysis improves baroreflex effectiveness index of end-stage renal disease patients. *J Hypertens* 26: 1795–1800, 2008
42. Culleton BF, Asola MR: The impact of short daily and nocturnal hemodialysis on quality of life, cardiovascular risk and survival. *J Nephrol* 24: 405–415, 2011
43. Culleton BF, Walsh M, Klarenbach SW, Mortis G, Scott-Douglas N, Quinn RR, Tonelli M, Donnelly S, Friedrich MG, Kumar A, Mahallati H, Hemmelgarn BR, Manns BJ: Effect of frequent nocturnal hemodialysis vs conventional hemodialysis on left ventricular mass and quality of life: A randomized controlled trial. *JAMA* 298: 1291–1299, 2007
44. McFarlane P, Komenda P: Economic considerations in frequent home hemodialysis. *Semin Dial* 24: 678–683, 2011
45. Sergeyeva O, Gorodetskaya I, Ramos R, Schiller BM, Larive B, Raimann JG, Ting GO, Eggers PW, Chertow GM, Levin NW; Frequent Hemodialysis Network Trials Group: Challenges to enrollment and randomization of the Frequent Hemodialysis Network (FHN) Daily Trial. *J Nephrol* 25: 302–309, 2012
46. Foley RN, Gilbertson DT, Murray T, Collins AJ: Long interdialytic interval and mortality among patients receiving hemodialysis. *N Engl J Med* 365: 1099–1107, 2011
47. Kerr PG, Agar JW, Hawley CM: Alternate night nocturnal hemodialysis: The Australian experience. *Semin Dial* 24: 664–667, 2011
48. Weinhandl ED LJ, Gilbertson DT, Arneson TJ, Collins AJ: Survival in daily home hemodialysis and matched thrice-weekly in-center hemodialysis patients. *J Am Soc Nephrol* 23: 895–904, 2012
49. Juergensen PH, Gorban-Brennan N, Troidle L, Finkelstein FO: Racial differences and peritonitis in an urban peritoneal dialysis center. *Adv Perit Dial* 18: 117–118, 2002
50. Fong E, Bargman JM, Chan CT: Cross-sectional comparison of quality of life and illness intrusiveness in patients who are treated with nocturnal home hemodialysis versus peritoneal dialysis. *Clin J Am Soc Nephrol* 2: 1195–1200, 2007
51. Hall YN, Larive B, Painter P, et al: Effects of six versus three times per week hemodialysis on physical performance, health, and functioning: Frequent Hemodialysis Network (FHN) randomized trials. *Clin J Am Soc Nephrol* 7: 782–794, 2012
52. Jaber BL, Finkelstein FO, Glickman JD, Hull AR, Kraus MA, Leypoldt JK, Liu J, Gilbertson D, McCarthy J, Miller BW, Moran J, Collins AJ; FREEDOM Study Group: Scope and design of the Following Rehabilitation, Economics and Everyday-Dialysis Outcome Measurements (FREEDOM) Study. *Am J Kidney Dis* 53: 310–320, 2009
53. Marshall MR, Hawley CM, Kerr PG, Polkinghorne KR, Marshall RJ, Agar JW, McDonald SP: Home hemodialysis and mortality risk in Australian and New Zealand populations. *Am J Kidney Dis* 58: 782–793, 2011
54. Seligman ME: Depression and learned helplessness. In: *The Psychology of Depression; Contemporary Theory and Research*, edited by Friedman R J, Katz MN, Washington, DC, Halsted Press, 1974, pp 83–111
55. Helanterä I, Haapio M, Koskinen P, Grönhagen-Riska C, Finne P: Employment of patients receiving maintenance dialysis and after kidney transplant: A cross-sectional study from Finland. *Am J Kidney Dis* 59: 700–706, 2012
56. Muehrer RJ, Schatell D, Witten B, Gangnon R, Becker BN, Hofmann RM: Factors affecting employment at initiation of dialysis. *Clin J Am Soc Nephrol* 6: 489–496, 2011
57. Berkowitz R: Finding freedom on a cruise. *Nephrol News Issues* 24: 42, 2010
58. Harper G: On the road...again: Now more than ever, dialysis can be part of the destination. *Nephrol News Issues* 23: 39–41, 2009
59. Korevaar JC, Feith GW, Dekker FW, van Manen JG, Boeschoten EW, Bossuyt PM, Krediet RT; NECOSAD Study Group: 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
60. 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
61. Stack AG: Determinants of modality selection among incident US dialysis patients: Results from a national study. *J Am Soc Nephrol* 13: 1279–1287, 2002
62. Lameire N, Van Biesen W: The pattern of referral of patients with end-stage renal disease to the nephrologist—a European survey. *Nephrol Dial Transplant* 14[Suppl 6]: 16–23, 1999
63. McLaughlin K, Jones H, VanderStraeten C, Mills C, Visser M, Taub K, Manns B: Why do patients choose self-care dialysis? *Nephrol Dial Transplant* 23: 3972–3976, 2008
64. McLaughlin K, Manns B, Mortis G, Hons R, Taub K: Why patients with ESRD do not select self-care dialysis as a treatment option. *Am J Kidney Dis* 41: 380–385, 2003
65. Troidle LK, Gorban-Brennan N, Kliger AS, Finkelstein FO: Peritonitis in the extended-care facility. *Adv Perit Dial* 14: 127–130, 1998
66. Wuerth D, Finkelstein SH, Ciarcia J, Peterson R, Kliger AS, Finkelstein FO: Identification and treatment of depression in a cohort of patients maintained on chronic peritoneal dialysis. *Am J Kidney Dis* 37: 1011–1017, 2001
67. Belasco A, Barbosa D, Bettencourt AR, Diccini S, Sesso R: Quality of life of family caregivers of elderly patients on hemodialysis and peritoneal dialysis. *Am J Kidney Dis* 48: 955–963, 2006
68. Suri RS, Larive B, Garg AX, Hall YN, Pierratos A, Chertow GM, Gorodetskeya I, Kliger AS; FHN Study Group: Burden on caregivers as perceived by hemodialysis patients in the Frequent Hemodialysis Network (FHN) trials. *Nephrol Dial Transplant* 26: 2316–2322, 2011
69. Wuerth DB, Finkelstein SH, Schwetz O, Carey H, Kliger AS, Finkelstein FO: Patients' descriptions of specific factors leading to modality selection of chronic peritoneal dialysis or hemodialysis. *Perit Dial Int* 22: 184–190, 2002
70. Pipkin M, Eggers PW, Larive B, Rocco MV, Stokes JB, Suri RS, Lockridge RS Jr; Frequent Hemodialysis Network Trial Group: Recruitment and training for home hemodialysis: Experience and lessons from the Nocturnal Dialysis Trial. *Clin J Am Soc Nephrol* 5: 1614–1620, 2010
71. Finkelstein FO, Story K, Firanek C, Barre P, Takano T, Soroka S, Mujais S, Rodd K, Mendelssohn D: Perceived knowledge among patients cared for by nephrologists about chronic kidney disease and end-stage renal disease therapies. *Kidney Int* 74: 1178–1184, 2008
72. Mehrotra R, Blake P, Berman N, Nolph KD: An analysis of dialysis training in the United States and Canada. *Am J Kidney Dis* 40: 152–160, 2002
73. Golper T, Schreiber M: The course of therapy—changing the paradigm. In: *Issues in Dialysis*, edited by Fadem S, New York, NY, Nova Science Publishers, 2012, pp 35–47
74. Clark WR, Turk JE Jr: The NxStage System One. *Semin Dial* 17: 167–170, 2004
75. Gura V, Beizai M, Ezon C, Polaschegg HD: Continuous renal replacement therapy for end-stage renal disease. The wearable artificial kidney (WAK). *Contrib Nephrol* 149: 325–333, 2005
76. Merrill JP, Schupak E, Cameron E, Hampers CL: Hemodialysis in the home. *JAMA* 190: 468–470, 1964
77. Buxton MJ, West RR: Cost-benefit analysis of long-term haemodialysis for chronic renal failure. *BMJ* 2: 376–379, 1975
78. De Vecchi AF, Dratwa M, Wiedemann ME: Healthcare systems and end-stage renal disease (ESRD) therapies—an international review: costs and reimbursement/funding of ESRD therapies. *Nephrol Dial Transplant* 14[Suppl 6]: 31–41, 1999

79. Friedman EA, Delano BG, Butt KM: Pragmatic realities in uremia therapy. *N Engl J Med* 298: 368–371, 1978
80. Goeree R, Manalich J, Grootendorst P, Beecroft ML, Churchill DN: Cost analysis of dialysis treatments for end-stage renal disease (ESRD). *Clin Invest Med* 18: 455–464, 1995
81. Kroeker A, Clark WF, Heidenheim AP, Kuenzig L, Leitch R, Meyette M, Muirhead N, Ryan H, Welch R, White S, Lindsay RM: An operating cost comparison between conventional and home quotidian hemodialysis. *Am J Kidney Dis* 42[Suppl]: 49–55, 2003
82. Lee H, Manns B, Taub K, Ghali WA, Dean S, Johnson D, Donaldson C: Cost analysis of ongoing care of patients with end-stage renal disease: The impact of dialysis modality and dialysis access. *Am J Kidney Dis* 40: 611–622, 2002
83. McFarlane PA, Pierratos A, Redelmeier DA: Cost savings of home nocturnal versus conventional in-center hemodialysis. *Kidney Int* 62: 2216–2222, 2002
84. Lacson E Jr, Wang W, DeVries C, Leste K, Hakim RM, Lazarus M, Pulliam J et al Effects of a nationwide predialysis educational program on modality choice, vascular access, and patient outcomes. *Am J Kidney Dis* 58: 235–242, 2011
85. Saggi SJ, Allon M, Bernardini J, Kalantar-Zadeh K, Shaffer R, Mehrotra R: Considerations in the optimal preparation of patients for dialysis. *Nat Rev Nephrol* 8: 381–389, 2012
86. Manns BJ, Taub K, Vanderstraeten C, Jones H, Mills C, Visser M, McLaughlin K: The impact of education on chronic kidney disease patients' plans to initiate dialysis with self-care dialysis: A randomized trial. *Kidney Int* 68: 1777–1783, 2005
87. Allen JR, Troidle LK, Juergensen PH, Kliger AS, Finkelstein FO: Incidence of peritonitis in chronic peritoneal dialysis patients infused with intravenous iron dextran. *Perit Dial Int* 20: 674–678, 2000
88. Afolalu B, Troidle L, Osayimwen O, Bhargava J, Kitsen J, Finkelstein FO: Technique failure and center size in a large cohort of peritoneal dialysis patients in a defined geographic area. *Perit Dial Int* 29: 292–296, 2009
89. Johansen KL, Zhang R, Huang Y, Chen SC, Blagg CR, Goldfarb-Rumyantzev AS, Hoy CD, Lockridge RS Jr, Miller BW, Eggers PW, Kutner NG: Survival and hospitalization among patients using nocturnal and short daily compared to conventional hemodialysis: a USRDS study. *Kidney Int* 76: 984–990, 2009
90. Van Eps CL, Jones M, Ng T, Johnson DW, Campbell SB, Isbel NM, Mudge DW, Beller E, Hawley CM: The impact of extended-hours home hemodialysis and buttonhole cannulation technique on hospitalization rates for septic events related to dialysis access. *Hemodial Int* 14: 451–463, 2010
91. Ward J, Shaw K, Davenport A: Patients' perspectives of constant-site (buttonhole) cannulation for haemodialysis access. *Nephron Clin Pract* 116: c123–c127, 2010
92. Labriola L, Crott R, Desmet C, André G, Jadoul M: Infectious complications following conversion to buttonhole cannulation of native arteriovenous fistulas: A quality improvement report. *Am J Kidney Dis* 57: 442–448, 2011
93. Hawley CM, Jeffries J, Nearhos J, Van Eps C: Complications of home hemodialysis. *Hemodial Int* 12[Suppl 1]: S21–S25, 2008
94. Lockridge RS Jr, Pipkin M: Short and long nightly hemodialysis in the United States. *Hemodial Int* 12[Suppl 1]: S48–S50, 2008
95. Granja CA, Juergensen P, Finkelstein FO: Phosphate balance in peritoneal dialysis patients: Role of ultrafiltration. *Contrib Nephrol* 163: 198–205, 2009
96. Cafazzo JA, Leonard K, Easty AC, Rossos PG, Chan CT: Patient-perceived barriers to the adoption of nocturnal home hemodialysis. *Clin J Am Soc Nephrol* 4(4): 784–789, 2009
97. Zhang AH, Bargman JM, Lok CE, Porter E, Mendez M, Oreopoulos DG, Chan CT: Dialysis modality choices among chronic kidney disease patients: identifying the gaps to support patients on home-based therapies. *Int Urol Nephrol* 42(3): 759–764, 2010

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