

A Systematic Approach to Promoting Home Hemodialysis During End Stage Kidney Disease

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Abstract

Home dialysis has garnered much attention since the advent of the Advancing American Kidney Health initiative. For many patients and nephrologists, home dialysis and peritoneal dialysis are synonymous. However, home hemodialysis (HHD) should not be forgotten. Since 2004, HHD has grown more rapidly than other dialytic modalities. The cardinal feature of HHD is customizability of treatment intensity, which can be titrated to address the vexing problems of volume and pressure loading during interdialytic gaps and ultrafiltration intensity during each hemodialysis session. Growing HHD utilization requires commitment to introducing patients to the modality throughout the course of end-stage kidney disease. In this article, we describe a set of strategies for introducing HHD concepts and equipment. First, patients initiating dialysis may attend a transitional care unit, which offers an educational program about all dialytic modalities during three to five weeks of in-facility hemodialysis, possibly using HHD equipment. Second, prevalent hemodialysis patients may participate in “trial run” programs, which allow patients to experience increased treatment frequency and HHD equipment for several weeks, but without the overt commitment of initiating HHD training. In both models, perceived barriers to HHD, including fear of equipment, anxiety about self-cannulation, catheter dependence, and the absence of a care partner, can be addressed in a supportive setting. Third, peritoneal dialysis patients who are nearing a transition to hemodialysis may be encouraged to consider a home-to-home transition (*i.e.*, from peritoneal dialysis to HHD). Taken together, these strategies represent a systematic approach to growing HHD utilization in multiple phenotypes of dialysis patients. With the feature of facilitating intensive hemodialysis, HHD can be a key not only to satiating demand for home dialysis, but also to improving the health of dialysis patients.

Introduction

Home hemodialysis (HHD) remains the least utilized dialytic modality in the United States (US), despite its old age—Merrill and Scribner started HHD programs in Boston and Seattle, respectively, in 1965¹; widespread utilization in the 1970s, with one-third of US patients undergoing HHD²; and a modern renaissance that began in 2005, when equipment that was designed for easy installation and use in the home was cleared by the US Food and Drug Administration (FDA).³ According to the United States Renal Data System, slightly less than 2% of dialysis patients underwent HHD at the end of 2017.⁴ Whether this proportion could or should increase is a curious topic, insofar as aspirations regarding the growth of home dialysis typically revolve around peritoneal dialysis (PD). In this article, we do not aim to pit HHD and PD in a battle of home dialysis superiority, as some observational studies have endeavored. Both HHD and PD have important roles. Nevertheless, considering the pathophysiology of contemporary dialysis patients and the aims of the Advancing American Kidney Health initiative,⁵ we contend that widespread availability of intensive HHD is a necessary ingredient in a successful system.

In this article, we describe the role of HHD in the dialytic armamentarium, with emphasis on customizing treatment frequency and duration to manage volume; construction of transitional care units (TCUs) that encourage HHD; trial utilization of HHD equipment in the facility setting; approaches to expanding the set of HHD candidates from prototypical “healthy patients” to those with perceived limitations; and integration of PD and HHD during a patient’s life-plan.

Volume Control and the Heart

For decades, the adequacy of dialysis has been defined by the total clearance of urea. By that measure, in-facility hemodialysis (IHD) in the US is very effective. Mean single-pool Kt/V is

1.6, and 97% of treatments deliver single-pool $Kt/V \geq 1.2$.^{4,6} Essentially, contemporary IHD is equivalent to the high-dose, high-flux arm of the HEMO trial.⁷ Nevertheless, age-adjusted rates of cardiovascular death and hospitalization in US dialysis patients are highly elevated, relative to the general population.⁴ Furthermore, the rate of all-cause death in dialysis patients has failed to decline during the last five years.⁸ Logic dictates that uremia is not the dominant pathophysiologic mechanism. Of course, there may not be a dominant mechanism. Ischemic events, arrhythmias, hemorrhage, and infection all contribute to limited survival.

However, we contend that focusing on fluid overload is highly likely to yield substantial improvement. In a European consensus statement, Sarafidis *et al* wrote, “Sodium and volume excess appear to be the most important causes of hypertension in dialysis patients.”⁹ In 2014, chief medical officers of US dialysis providers proposed a “Volume First” strategy and argued that “extracellular fluid status should be a component of sufficient hemodialysis.”¹⁰ Despite this encouragement, evidence of progress is limited. Surveillance data indicate that intradialytic weight loss decreased by 5% between 2014 and 2020, while session duration increased by 2%.⁶ Consequently, mean ultrafiltration rate (UFR) fell to 7.7 mL/hour/kg.⁶ Lower UFR should have improved outcomes, but the cardiovascular hospitalization rate in 2015-2017 was slightly higher than in 2012-2014.⁴ This constellation of changes suggests that some patients may be left “wet” in pursuit of lower UFR. A recent study using bioimpedance spectroscopy showed that 30% of IHD patients experience chronic fluid overload, which was associated with higher mortality at all levels of systolic blood pressure.¹¹

Three aspects of the hemodialysis prescription determine the nature of fluid accumulation and removal: dialysate sodium concentration, the duration of gaps between consecutive treatments, and cumulative treatment hours per week. In the SoLID trial, in which most patients

underwent thrice-weekly HHD, lowering dialysate sodium reduced interdialytic weight gain, but did not significantly reduce left ventricular mass and increased the odds of intradialytic hypotension.¹² These results suggest that uremic toxin clearance and hemodialysis intensity were not adequately addressed. In a study of 16 patients undergoing thrice-weekly hemodialysis, a cardiac microelectromechanical sensor device was used to record pulmonary pressures for eight days; one such recording is displayed in Figure 1.¹³ Right ventricular systolic pressure (RVSP) climbed immediately after each session. RVSP climbed further as time elapsed between each pair of consecutive treatments; *normal* RVSP was observed only at the end of hemodialysis. Another study detected markedly high incidence of bradycardia during the final hours of interdialytic gaps.¹⁴ Cyclical volume and pressure loading are probably inevitable with thrice-weekly hemodialysis. Anuric hemodialysis patients spend 93% of their time accumulating salt and water and merely 7% undergoing treatment to remove what was accumulated. This distortion of normal physiology presents a major challenge, insofar as retained fluid must be removed, but only at a sufficiently low rate to avoid iatrogenic effects, including myocardial stunning, hypotension, dizziness, and nausea.¹⁵

In many patients, successfully managing volume and reducing RVSP will require the completion of three objectives: (1) achievement of *true* dry weight; (2) an increase in weekly hours of kidney replacement therapy, thereby meeting cumulative ultrafiltration demand, but at an ultrafiltration rate that is sufficiently low to avoid intradialytic complications; and (3) an increase in frequency of therapy, thereby decreasing both peak RVSP during interdialytic gaps and the area under the RVSP curve. These objectives are in reach with proper prescription of HHD, which is customizable to the individualized needs of patients.

In general, we need to aim for better blood pressure control, both primary and secondary prevention of left ventricular hypertrophy, and significant reduction in risks of cardiovascular death and hospitalization. We also need to aim for symptom-free hemodialysis sessions, as numerous patients have loudly stated.¹⁶ Intensive HHD is one treatment that can address these needs.¹⁷⁻¹⁹ Indications for intensive HHD include persistent hypertension (which may present with pre-dialysis systolic blood pressure in goal range, but with use of ≥ 3 antihypertensive medications), left ventricular hypertrophy, heart failure, recurrent intradialytic hypotension, post-dialysis fatigue, and refractory hyperphosphatemia. Most of these indications are currently accepted by Medicare as justification for coverage of additional hemodialysis sessions.

Transitional Care Units: Promoting HHD in Incident Patients

Of 124,500 incident end-stage kidney disease (ESKD) patients in 2017, up to 33% received little or no nephrology care before dialysis initiation.⁴ Lack of preparation for the life-altering nature of maintenance dialysis exacts profound physical and emotional tolls on patients and their family members. In >303,000 patients who initiated dialysis in 1997-2009, with >94% undergoing IHD, mortality risk was 2.7 times greater and hospitalization risk was 2.0 times greater during dialysis weeks 1-2 versus week 53.²⁰ Greater utilization of home dialytic modalities may improve outcomes during the first year, but in 2017, only 0.4% and 10.4% of incident ESKD patients utilized HHD and PD, respectively.⁴ However, the efficacy and safety—including loss of residual function—of intensive HD in incident ESKD patients is ultimately uncertain.²¹

TCUs offer a better path forward for patients. This concept is not new, for it was initially described by Northwest Kidney Centers almost 40 years ago.²² Today, the TCU program can be defined by the following characteristics:

- A patient-centered educational program for *all* suitable patients initiating hemodialysis, with a usual duration of three to five weeks;
- More frequent hemodialysis at gentle (*i.e.*, slower) rates of blood and/or dialysate flow, preferably using the HHD machine of choice (although a combination of conventional and home-optimized hemodialysis machines may be employed);
- Staff effort focused on addressing fears and preconceived ideas about dialysis;
- Identification of both medical *and* lifestyle goals of the patient;
- Provision of unbiased education about all renal replacement therapies, including IHD, HHD, and PD, and kidney transplant;
- Provision of education about vascular access and financial considerations.

Table 1 displays suggested patient selection criteria for a TCU program.

A comprehensive curriculum that is delivered by a multidisciplinary team, which must include nurses, technicians, dietitians, social workers, financial coordinators, nurse practitioners, physician assistants, and nephrologists, is critical to the success of the TCU program. Although the curricula and designs of TCU programs may vary among dialysis organizations, programs generally adopt an intensive curriculum of three to five weeks. A sample curriculum is displayed in Table 2. We recommend that a defined group of patient care technicians and nurses staff the TCU. These team members should be fluent in technical and practical aspects of home dialytic modalities and encouraged to speak enthusiastically about the benefits of the modalities.

Data about utilization of home dialytic modalities in TCU program graduates have been promulgated primarily in published abstracts. These data suggest that among patients with a “crash start” into dialysis (*i.e.*, patients who received no pre-ESKD education and initiated dialysis in a hospital), between 30% and 75% will select a home dialytic modality; among those patients, between 25% and 50% will select HHD.²³⁻²⁶ More research is needed.

There is consensus that TCUs should be designed to give patients firsthand experience with home dialysis equipment and the opportunity to interact with prevalent ESKD patients who are undergoing PD, HHD, and IHD; if time permits, interaction with patients who have a functioning transplant may also be worthwhile. TCUs can be standalone units or incorporated into an existing IHD unit or a home therapies unit, as displayed in the schematics in Figure 2. The number of chairs that are needed in the TCU should reflect the monthly sum of incident ESKD patients, PD technique failure cases, and graft failure cases within a catchment area or nephrology practice. Although schematics depict HHD machines beside TCU chairs, some programs may employ conventional hemodialysis machines.

Hemodialysis prescriptions in TCU programs should prioritize both increased treatment frequency (≥ 4 sessions per week) and relatively low ultrafiltration rates (≤ 8 mL/hour/kg). Two-day gaps between consecutive treatments should be avoided, although local issues pertaining to staffing and economics may preclude TCU operations on weekends. Other goals may include blood flow rate of 300-400 mL/min²⁷ and standardized Kt/V of 2.3.²⁸

Obtaining the assent of patients, physicians, nurses, healthcare system partners (including primary care physicians, hospital discharge planners, and acute dialysis staff), and allied dialysis organizations is critical to the success of the TCU program. Importantly, cherry-picking patients for the TCU is unlikely to be a good clinical or economic strategy.

Trial Run Programs: Promoting HHD in Prevalent Patients

Whereas TCU programs can be leveraged to introduce incident ESKD patients to HHD, trial run (TR) programs can be leveraged to introduce intensive HHD to all appropriate prevalent ESKD patients. Table 1 includes phenotypes of patients who could benefit from the opportunity to dialyze more frequently with HHD equipment. Patients can participate in TR programs for up to two weeks. This duration allows patients an opportunity to experience some of the physical benefits (*e.g.*, shorter post-dialysis recovery time) of more frequent hemodialysis and to see the simplicity of equipment that is designed for use at home. TR programs offer an excellent time to educate patients about technical and practical aspects of HHD. Table 3 displays a sample curriculum. Hemodialysis prescriptions in TR program should be like those in TCU programs, with biases favoring increased treatment frequency, shorter session duration, and lower ultrafiltration intensity. Patients who participate in TR programs may quickly report feeling better and having more energy.²⁹

In the US, TR programs are most often operated in facilities that include one or two treatment stations featuring the HHD machine of choice. Patient care technicians and nurses who ordinarily work in the dialysis facility can be trained to operate home equipment, but education is typically provided by the home therapies team. If space is available, the TR program can be operated in the home dialysis clinic or as part of a TCU. It is important that the home therapies team carefully supervise the effects of changing the hemodialysis prescription, with attention to volume status, blood pressure, and vascular access health. Patients may need to discontinue antihypertensive medications to avoid hypotensive episodes. During a patient's time in the TR program, the nephrologist and nurse should review the home environment, the patient's work

schedule (if the patient is employed), the presence and capability of any potential care partner, and the patient's lifestyle preferences, so that the patient and family members can make an informed choice about initiating HHD training. Work schedules and care partner status may necessitate additional discussion about therapy adaptations.

Addressing Barriers to HHD

A systematic approach to addressing patient and provider barriers to HHD adoption is essential to facilitating HHD growth. Important barriers include fear of HHD equipment, fear of self-cannulation, anxiety about the safety of HHD, perceived impracticality of HHD, and the lack of critical mass (*i.e.*, patient volume) in a home therapies unit. Continually educating patients, families, and staff is important. Table 4 identifies approaches to educating these parties.

Given the limited health literacy of some dialysis patients,³⁰ fear of HHD equipment is a real challenge for patients and family members.³¹ Even dialysis provider staff who are unfamiliar with HHD may harbor or express anxiety about equipment. It is important that patients undergo treatment with the HHD machine of choice in TCU and TR programs. Without this experience, patients may naively assume that HHD is possible only if conventional equipment is installed in the home. Fear of self-cannulation is another substantial problem for patients who are initiating HHD.³² Interventions to address this fear include hand holding, topical analgesia, peer modeling, relaxation techniques, and hypnotherapy.³³ Self-cannulation can be taught in the TCU, thereby allowing patients and staff to focus on learning about HHD during HHD training.

Following the efforts of the “Fistula First” and “Fistula First Catheter Last” coalitions, many home dialysis programs permit HHD only with an arteriovenous fistula. This policy is often justified by a claim of uncertain safety of HHD with a central venous catheter. However,

associations of vascular access type and mortality risk are similar in HHD patients and in-facility HD patients.³⁴⁻³⁶ The Kidney Disease Outcomes Quality Initiative Clinical Practice Guideline for Vascular Access: 2019 Update has recommended that patients and nephrologists create an ESKD life-plan, including vascular access choice.³⁷ The update notes that there is inadequate evidence about relative risks of clinical outcomes to recommend a vascular access type in prevalent ESKD patients, thereby facilitating the adoption of a new strategy for vascular access in patients who wish to select HHD. Approximately 20% of US HHD patients utilize a central venous catheter.³⁶ A patient who does not have a functioning arteriovenous access can initiate HHD with a catheter, initiate treatment in the home setting, and subsequently learn how to cannulate.

Studies indicate that >25% of US dialysis patients are either unmarried or widowed.³⁸ It is plausible that many of these patients lack a care partner and are discouraged from pursuing HHD. However, HHD without a care partner is not uncommon in other high-income countries.³⁹ The nephrologist should have a discussion with the interested patient about the risks of “solo” therapy—which has been evaluated by the US FDA and explicitly cleared with one machine—and the dialysis provider should employ safety provisions for patients who choose to dialyze without a partner. Some patients, with or without a partner, may perceive their residence as an impractical site for HHD. Identifying solutions for supply delivery and storage is necessary.

There is also a need for a critical mass of HHD patients in the training unit for the home dialysis program to be successful. Patient volume improves quality of training and follow-up in home dialysis programs. A regional HHD training unit can facilitate critical mass.⁴⁰ Ultimately, both nephrologists and dialysis providers should adopt an approach of finding barriers to HHD and offering resources to resolve those barriers. An “open door” to HHD will allow programs to reach a critical mass.

Integrating Peritoneal Dialysis with HHD

Dialytic modality selections should reflect thoughtful evaluation and informed consent. For patients who initiate dialysis in the home, selection of another modality in the future is likely.⁴¹ Preparing patients to make these selections is an important task for nephrologists. Patients must always understand that poorly managed health will render life goals more difficult to achieve. Nephrologists should guide patients toward sequencing dialytic modalities to achieve the highest quality-adjusted survival, considering the patient's life goals. The nephrologist's obligation is to recommend a course of action, but the recommendation should be accompanied by an explanation of reasons for the treatment selection or change, the anticipated benefits, and the possible risks, as well as the risks that are associated with declining the recommendation. Both medical and emotional states of the patient should be considered when selecting an initial modality (*e.g.*, PD) and transitioning from one modality to another (*i.e.*, from PD to HHD) at an appropriate time.

Although cumulative time with any dialytic modality depends on intercurrent events and provider-specific factors, the median duration of PD in incident ESKD patients ranges from two to four years.⁴² The median duration of HHD is comparable.⁴¹ Patient factors to consider when recommending either PD or HHD as the initial home dialysis modality are displayed in Table 5.

In most ESKD patients, including incident patients who undergo dialysis at home, one type of kidney replacement therapy will not be effective during the entirety of a patient's life. The concept of an integrated home dialysis model leverages the patient's home as the preferred site of disease management.⁴³ The sequence proposes that patients initiate dialysis with PD and, when a transition point is reached, shift to HHD, instead of in-facility hemodialysis. On average,

patients who experience PD technique failure may benefit from switching to HHD.⁴⁴ However, home-to-home transitions have been rare. Table 6 displays the three phases of a structured integrated home dialysis model: the modality response phase, the intermediate response phase, and the transition point phase. Home-to-home transitions can be timed to coincide with changes in residual renal function, ventricular mass, and mineral and bone disease.

Conclusion

Despite excellent treatment of uremia, quality-adjusted survival of dialysis patients is lagging. Poor management of volume is a probable culprit. Due to its inherent customizability, HHD is an effective modality for limiting interdialytic gaps and reducing ultrafiltration intensity. To promote growth of home dialysis generally and HHD specifically, HHD should be repeatedly offered during a patient's life. TCU programs can be leveraged to introduce HHD concepts and equipment to incident ESKD patients undergoing hemodialysis; TR programs can be likewise leveraged in prevalent hemodialysis patients. PD and HHD can be integrated to increase the likelihood of home-to-home transitions. With this multipronged approach, HHD can be a key to improving dialysis patient health.

Disclosures

R Lockridge reports speaker honoraria from DaVita Kidney Care, Fresenius Medical Care North America, and NxStage Medical. E Weinhandl reports acting as consultant to Fresenius Medical Care North America. M Kraus reports employment at Fresenius Medical Care North America. M Schreiber reports employment at DaVita Kidney Care. L Spry reports stock in a for-profit joint venture, Lincoln Nephrology Investments, regarding a facility offering only home dialysis. P Taylor reports scientific advisory board of NxStage Medical. M Carver reports employment at DaVita Kidney Care. J Glickman reports authorship of UpToDate content; medical advisory board of Cricket Health; speaker honorarium from Home Dialysis University. B Miller reports authorship of UpToDate content; speaker honoraria from DaVita Kidney Care, Fresenius Medical Care Renal Therapies Group, and Home Dialysis University.

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Table 1. Patient criteria for transitional care unit and trial run programs.

Patients who are candidates for a TCU program
<ul style="list-style-type: none">• Incident ESKD patients who have not already chosen a home therapy• Failing peritoneal dialysis and expected to change modality• Failing kidney transplant and expected to initiate dialysis
Patients who are candidates for a TR program
<ul style="list-style-type: none">• Undergoing IHD and employed, including by childcare at home• Undergoing IHD and expected to be wait-listed for a kidney transplant for >4 years• Undergoing IHD with ejection fraction <45%• Undergoing IHD with chronic fluid overload and use of ≥ 2 antihypertensive medications• Undergoing IHD with unstable cardiovascular status (<i>e.g.</i>, ≥ 2 hospital admissions during previous 6 months)• Undergoing IHD with frequent intradialytic hypotension• Undergoing IHD with repeated isolated ultrafiltration sessions• Failing peritoneal dialysis• Failing kidney transplant
Patients who are <i>not</i> candidates for either TCU or TR programs
<ul style="list-style-type: none">• Permanent resident of long-term care facility and without a care partner• In hospice• Significant cognitive impairment precluding meaningful participation• Unstable living arrangement

Abbreviations: ESKD, end-stage kidney disease; IHD, in-facility hemodialysis; TCU, transitional care unit; TR, trial run.

Table 2. Sample schedule for transitional care unit program.

Week 1: Welcome to the TCU
<ul style="list-style-type: none">• Explain purpose of TCU and introduce team members• Discuss patient's goals, concerns, and fears• Adjust hemodialysis prescription and medications
Week 2: Education
<ul style="list-style-type: none">• Discuss benefits, risks, and expected outcomes associated with IHD, HHD, PD, kidney transplant, and conservative care• Discuss vascular access types• Discuss and address vaccination• Adjust hemodialysis prescription and medications
Week 3: Ongoing education and selection
<ul style="list-style-type: none">• Continue education with home therapies team• Facilitate interaction with other home dialysis patients• Allow patients to see and experience HHD equipment• Ascertain decisions about continuation of dialysis and dialytic modality• Initiate referral for creation of vascular access (as applicable)• Adjust hemodialysis prescription and medications
Week 4: Graduation
<ul style="list-style-type: none">• Transition to appropriate dialysis setting• Confirm plan for creation of vascular access• Confirm transplant evaluation appointments• If conservative management is selected, then arrange palliative care or hospice• Discuss advanced care planning

Abbreviations: HHD, home hemodialysis; IHD, in-facility hemodialysis; PD, peritoneal dialysis;

TCU, transitional care unit.

Table 3. Sample curriculum for trial run program.

Day 1

- Frequency and schedule of HHD, relative to in-facility hemodialysis
- HHD without a care partner, as appropriate

Day 2: Introduce the technical components

- Machine
- User interface (displays, buttons)
- Cartridge
- Dialysate

Day 3: Explain the benefits and risks of HHD

Day 4: Describe self-cannulation

- Probe patient's interest in or fear of self-cannulation
- Describe techniques to overcome fear, as is necessary
- Discuss use of a central venous catheter for vascular access

Day 5: Invite a current HHD patient to share experience.

- Training
 - Daily routine at home
 - Impact of frequent hemodialysis on health and quality of life
 - Cannulation
 - Patient responsibilities
 - Care partner role
-

Abbreviations: HHD, home hemodialysis.

Table 4. Approaches to introducing home hemodialysis concepts and technology to end-stage kidney disease patients, family members, and health care professionals.

Group	Educational program	Duration	Educators
Patients	TCU	3-5 weeks	TCU staff (RNs, LPNs, PCTs) and HT nurse
	TR	1-2 weeks	TR staff (RNs, LPNs, PCTs) and HT nurse
Family members	1-hour program about HHD and equipment	1-2 appointments	Social worker and HT nurse
IHD RNs, LPNs, and PCTs	2-hour program about HHD and equipment	During IHD orientation	IHD educator and HT nurse
Dietitians and social workers	1-hour program about HHD and equipment	During IHD orientation	IHD educator and HT nurse
Nephrologists	1-hour program about HHD and equipment	During IHD orientation	HT nurse

Abbreviations: HHD, home hemodialysis; HT, home therapies; IHD, in-facility hemodialysis; LPN, licensed practical nurse; PCT, patient care technician; RN, registered nurse; TCU, transitional care unit; TR, trial run.

Table 5. Patient characteristics to consider in selection of either peritoneal dialysis or home hemodialysis as an initial home dialytic modality; characteristics were adapted from the Method to Assess Treatment Choices for Home Dialysis (MATCH-D) tool (Medical Education Institute, Madison, Wisconsin).

Peritoneal dialysis		
Medical indications	Psychosocial determinants	Possible barrier
<ul style="list-style-type: none"> • Residual renal function • Edema • Suboptimal blood pressure • Mild LV hypertrophy • Right-sided heart failure • History of heart failure hospitalization(s) 	<ul style="list-style-type: none"> • Full-time employment, including childcare at home • Desire to travel • Phobia of needles • Transportation problems • Awaiting living donor kidney transplant • Body image concerns regarding vascular access 	<ul style="list-style-type: none"> • Homelessness • Uncontrolled anxiety or psychosis • Poor hand dexterity, despite adaptations • Active inflammatory bowel disease • History of complex abdominal surgeries • Anuria and BSA >2.0 m²
Home hemodialysis		
Medical indications	Psychosocial determinants	Possible barrier
<ul style="list-style-type: none"> • Urine volume <250 mL/day and serum phosphorus >8.0 mg/dL • Ultrafiltration rate >13 mL/kg/hr with thrice-weekly IHD • Uncontrolled hypertension • Moderate LV hypertrophy • Right-sided heart failure • Obesity, possibly with obstructive sleep apnea and/or use of CPAP 	<ul style="list-style-type: none"> • Full-time employment, including childcare at home • Desire to travel • Transportation problems • Desire control of treatment schedule • Body image concerns regarding PD catheter or distended abdomen 	<ul style="list-style-type: none"> • Homelessness • Uncontrolled anxiety or psychosis • Phobia of needles • Increased frailty • Blind or severely visually impaired

Abbreviations: BSA, blood pressure; CPAP, continuous positive airway pressure; IHD, in-facility hemodialysis; LV, left ventricular.

Table 6. Phases of an integrated home dialysis model that utilizes peritoneal dialysis as the first modality. In the early response phase, patients are generally stable and only minor adjustments to the peritoneal dialysis prescription are needed to achieve listed medical goals. In the intermediate response phase, listed signs of clinical deterioration may require more substantial changes to the peritoneal dialysis prescription and may signal an approaching transition to home hemodialysis. Finally, in the transition phase, serious adverse events signal an imminent need for transition to home hemodialysis.

Early response phase	Intermediate response phase	Transition point phase
<ul style="list-style-type: none"> • “No harm” prescription • Preserve residual renal function • Optimize volume control • Control blood pressure • Achieve nutritional balance • Design care to avoid hospitalizations 	<ul style="list-style-type: none"> • Decreasing residual renal function • Increasing serum phosphorus • Edema • Poorly controlled blood pressure • Worsening LV hypertrophy, per echocardiogram • Gradual decrease in functional status • >1 episode of peritonitis during the first year • Hospitalization rate >1.5 admissions per year • total $Kt/V < 1.7$ 	<ul style="list-style-type: none"> • Urine volume <250 mL/day with progressive LV hypertrophy • Phosphorus >6.0 mg/d or uncontrolled SHPT • Ultrafiltration failure • Uncontrolled hypertension, with blood pressure >150/90 mmHg • Loss in lean body mass • Weight gain >15 kg • Uncontrolled hyperglycemia and/or HbA1c >7.0% • Recurrent peritonitis during the first year • total $Kt/V < 1.7$, despite multiple prescription changes

Abbreviations: LV, left ventricular; SHPT, secondary hyperparathyroidism; std, standardized.

Figure 1.

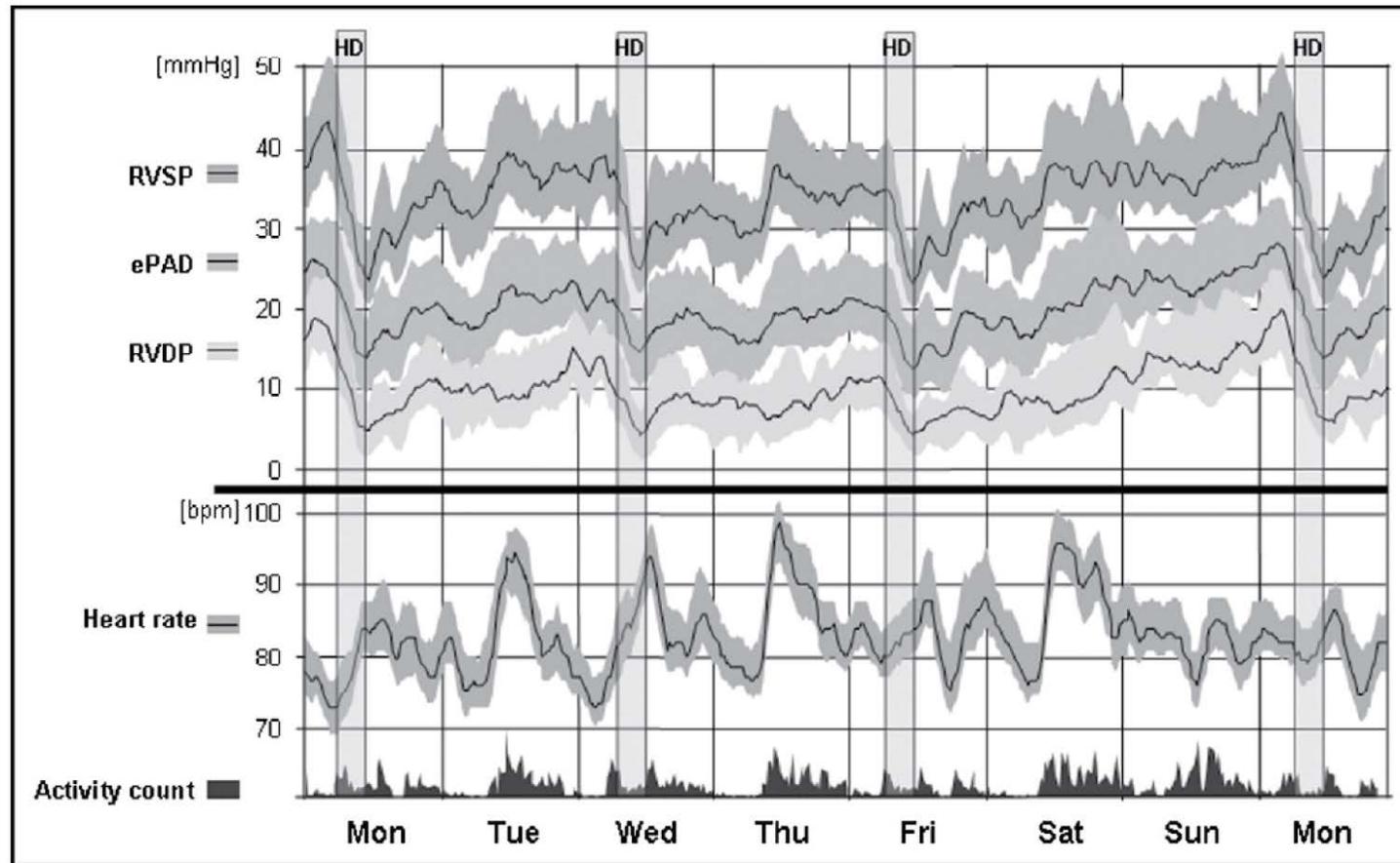


Figure 1. Eight-day continuous hemodynamic trend from a patient who underwent thrice-weekly hemodialysis. A marked reduction in right ventricular systolic pressure occurred during each dialysis session, followed by progressive pressure increments until the next dialysis session. Abbreviations: ePAD, estimated pulmonary arterial diastolic; HD, hemodialysis; RVDP, right ventricular diastolic pressure; RVSP, right ventricular systolic pressure. Borrowed with permission from Kjellström *et al.*¹³

Figure 2.

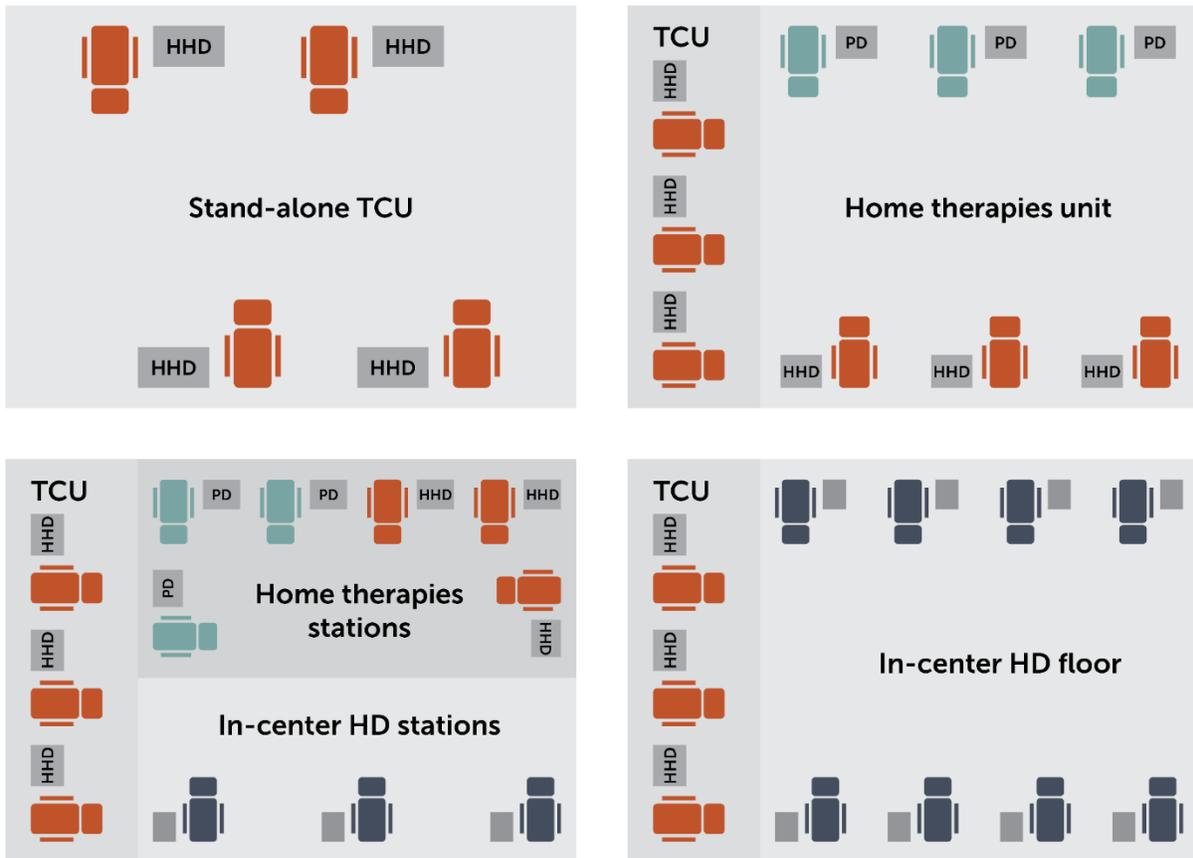


Figure 2. Schematics of transitional care unit floor plans. These schematics depict a stand-alone transitional care unit (upper left), a home therapies training unit that includes a transitional care unit (upper right), a home therapies training unit that includes both a transitional care unit and in-center hemodialysis stations (lower left), and an in-center hemodialysis floor that includes a transitional care unit (lower right). Abbreviations: HD, hemodialysis; HHD, home hemodialysis; PD, peritoneal dialysis; TCU, transitional care unit.