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FOR

KIDNEY CARE PROFESSIONALS

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THE ADVANCING AMERICAN KIDNEY HEALTH EXECUTIVE ORDER

HOW THE ADVANCING AMERICAN KIDNEY HEALTH EXECUTIVE ORDER COULD AFFECT DIALYSIS CLINICS, PATIENTS AND KIDNEY CARE PROFESSIONALS

In the United States, dialysis is a large, profitable and continually growing business. Despite this, patient outcomes in the US fall behind those of other countries. Each year, Medicare spends $114 billion a year on Americans with kidney disease. Nearly **750,000 people in the United States are affected by end-stage renal disease** (ESRD), and that number is expected to increase by 5% each year. In an effort to reduce healthcare costs for ESRD and improve patient outcomes, President Trump signed an executive order revamping kidney care in the U.S. over the next 10 years. This piece will take a deep dive into the order, its proposals and how those proposals could affect clinicians, dialysis clinics and staff and patients.

What's Happening with Kidney Care in the United States

Advancing American Kidney Health

In July 2019, President Donald Trump signed an executive order — Advancing American Kidney Health — designed to "improve the lives of Americans suffering from kidney disease, expand options for American patients, and reduce healthcare costs," according to the **Department of Health and Human Services (HHS).**

The HHS has laid out three goals for improving kidney health in the U.S.:

1. Reduce the number of Americans with end-stage renal disease (ESRD) by 25% by 2025
2. Have 80% of new ESRD patients receiving either home dialysis or kidney transplants by 2025
3. Double the number of kidneys available for transplant by 2030

The Center for Medicare and Medicaid Innovation (CMMI) released four voluntary Comprehensive Kidney Care Contracting (CKCC) payment models and one mandatory payment model at the same time as the executive order. These payment models will provide financial incentives for better management of ESRD patients and improve rates of home dialysis, and kidney or kidney-pancreas transplants. The executive order will use these models to drive the changes it has laid out above.

Medicare-certified Clinics and Home Hemodialysis

According to homedialysis.org, there are 7,564 Medicare-certified dialysis clinics in the U.S. but only 21% are certified to provide home hemodialysis training and support. If selected clinics are not are certified to offer home hemodialysis training and support, an additional time and infrastructure investment might be needed to prepare clinics.

Voluntary CKCC Models

According to CMS, the models will have three distinct accountability frameworks:

CKCC GRADUATED MODEL: This model is based on the existing CEC Model One-Sided Risk Track – allowing certain participants to begin under a lower-reward, one-sided model and incrementally phase in to greater risk and greater potential reward.

CKCC PROFESSIONAL MODEL: This payment arrangement is based on the Professional Population-Based Payment option of the Direct Contracting Model – with an opportunity to earn 50% of shared savings or be liable for 50% of shared losses based on the total cost of care for Part A and B services.

CKCC GLOBAL MODEL: This payment arrangement is based on the Global Population-Based Payment option of the Direct Contracting Model – with risk for 100% of the total cost of care for all Parts A and B services for aligned beneficiaries.

The models are expected to run from January 1, 2020, through December 31, 2023.

Mandatory ESRD Treatment Choices (ETC) Model

The ETC Model notes that managing clinicians and dialysis clinics in certain geographic areas throughout the country that treat 50% of Medicare patients would be randomly selected to participate. Clinics can be excluded if they're in U.S. territories, treat too few patients or treat pediatric patients. Patients can be excluded if they live outside the U.S., are receiving dialysis due to acute kidney injury, have dementia, are under 18 or are in hospice. Patients can't opt out of the ETC Model if they're at a clinic that's been selected, but they can choose whether to receive dialysis from a provider under the model.

The model would extend kidney disease education to nurses, dietitians and social workers. Education would be expanded to Medicare patients with Stage 5 CKD and to Medicare patients who would have received an ESRD diagnosis within the last six months.

How Will Advancing American Kidney Health Affect Patients and Dialysis Clinics?

The Trump administration's executive order has the potential to fundamentally alter the treatment of ESRD patients in the United States. According to Kaiser Health News, 726,000 patients have ESRD in the United States. Of these, about 88% receive treatment in dialysis clinics with the other 12% receiving home dialysis.

The Potential Impact of Home Dialysis

Home hemodialysis has several benefits: It's more convenient, recovery times are faster, treatments can be individualized and the patient's quality of life is better. However, it's not right for everyone, particularly older adults with bad eyesight, poor fine-motor coordination, depression or cognitive impairment. Adults over age 65 make up half of the 125,000 people newly diagnosed with kidney failure each year.

Despite the benefits of home hemodialysis, patient retention remains an issue. The modality often sees discontinuation rates of between 20% to 25% within the first year. This can have a damaging effect on both the dialysis facilities and patients due to the large upfront costs that come with home hemodialysis.

A study in the *American Journal of Kidney Disease* wanted to define the factors associated with the discontinuation of home hemodialysis. Study authors followed 2,840 patients over a three-year period. At the end of the study, 729 patients had discontinued treatment. Researchers found patients who discontinued home hemodialysis were more likely to:

- Have diabetes
- Use tobacco, alcohol or recreational drugs
- Be less likely to be listed for kidney transplantation
- Live in a rural area

Strategies for Patient Retention

Eric Weinhandl, Ph.D., MS; Marienne Sanders, MS; Michael Kraus, MD; Michelle Carver, BSN, RN, CNN, outline these four patient retention strategies found in the most successful home hemodialysis programs.

TRAIN PATIENTS CONSISTENTLY AND WELL: Weinhandl, et al observed: "The risk for technique failure was more than 15% lower in programs training more than two patients per quarter versus in those who seldom or sporadically train." They also found care team members proactively met with the patients and/or partners and clearly outlined the home dialysis process.

GET THE PRESCRIPTION RIGHT FOR EACH PATIENT: Some patients who discontinued therapy did so because their prescription was not adjusted to their needs, or when they do not understand its rationale. As a result, Weinhandl, et al note: "The physician must be transparent in setting expectations for the patient and be responsive and attentive during training."

How are ESRD Patients Treated?

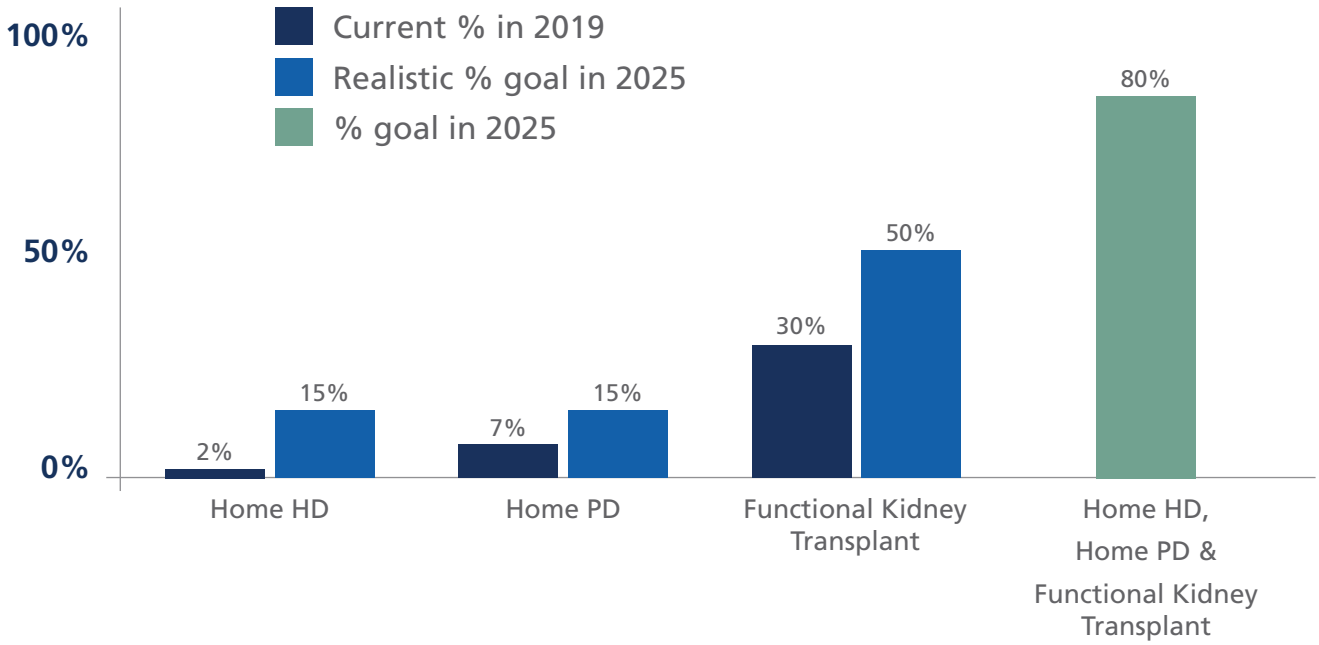
As of December 31, 2016, 63.1% of all prevalent ESRD patients were receiving hemodialysis therapy, 7% were treated with peritoneal dialysis (PD), and 29.6% had a functioning kidney transplant. Among hemodialysis cases, 98% used in-center hemodialysis, and 2% used home hemodialysis.

ENSURE PARTICIPATION OF THE INTERDISCIPLINARY TEAM, PARTICULARLY THE SOCIAL WORKER AND THE PATIENT CARE TECHNICIAN (PCT): In top-performing programs, the home hemodialysis program was not the sole responsibility of the home program nurse, but the responsibility of an integrated care team that included a variety of people including social workers and PCTs. Social workers supported patients throughout their home experience, while PCTs supported the home program nurses.

MONITOR AND GET ACTIVELY INVOLVED WHEN THE PREDICTORS OF PATIENT DISCONTINUATION – HOSPITALIZATION AND MISSED TREATMENTS – PRESENT THEMSELVES: Closely monitoring patients after they go home provides an opportunity to find and address those who are planning to discontinue therapy. Successful programs implemented timely interventions and offered respite care when patients displayed discontinuation triggers.

The administration's goal is for 80% of new ESRD patients to receive home dialysis or kidney transplant by 2025. Here's how much growth would have to occur in home hemodialysis, home PD and functional kidney transplant to make that a reality:

CURRENT % OF HOME HD, HOME PD AND SUCCESSFUL KIDNEY TRANSPLANTS NEED TO DOUBLE IN FIVE YEARS. HOWEVER, MORE REALISTIC GOALS MIGHT BE:



What Could Happen to the Dialysis Clinics?

At the end of 2016, there were 6,871 dialysis facilities in the U.S. treating 493,550 patients, according to the Centers for Disease Control. With Trump's executive order requiring 80% of new ESRD patients to receive either home dialysis or a transplant, it makes sense to wonder what will happen to existing dialysis facilities. As the order takes effect, clinics and staff may experience the following:

- There could be a reduction of new patients for in-center patient stations and staff for coverage.
- There could be a reduction of current patients and census could shift from in-center to home therapies.
- Home hemodialysis therapies training times could cause a bottleneck for new patient training – forcing patients to dialyze in-center until a home training slot opens.
- Teams may be swayed to convince patients to select home PD over home hemodialysis because PD training is quicker, which could increase training capacity.
- The need for respite care may increase and require stations in-center, which could require staff to learn various dialysis systems that the patient can use for their therapy.
- Vascular access care is a critical part of home hemodialysis. As a result, patients could be trained at the in-center stations as they await or decide to go fully into home hemodialysis training including access monitoring and cannulation.

How Could This Order Affect Dialysis Clinic Staff?

If you're employed at a dialysis clinic, you might be wondering how this executive order could affect your employment. Here are some things to consider:

- **For Nephrology Clinical Technicians and Nephrology Biomedical Technologists:** Learn about your specific state's nurse practice acts to understand the roles that might be available in the home therapy programs. Also, learn more about the role of patient education in the in-center facility provided by the Nephrology Clinical Technicians and Nephrology Biomedical Technologists.

- **For Nephrology Nurses:** Home therapies nurses are required to have three months of experience in the specific modality. Learning about opportunities to get more clinical experience with the home therapies will increase your career opportunities.

Here are some considerations of how these facilities could be used:

SELF-CARE CENTERS

Patients who participate in self-care have better outcomes than those who do not. Currently, self-care is included in the proposed new payment models for treatment in-center. The regulations do allow in-center patients to transition to various levels of self-care.

Self-care would not be counted toward the number of home dialysis patients in the new payment model. If it would be included as a variation of home dialysis, then the utilization of current dialysis facilities could provide a location of hemodialysis to any patient that has housing insecurity to dialyze safely.

Self-care is covered in the ESRD Conditions of Coverage V-Tag 582 which states, "A certified dialysis facility approved for outpatient maintenance dialysis services needs no additional certification or approval to provide in-center self-dialysis or to teach an in-center patient to perform all or part of their dialysis treatment (e.g., self-cannulate, monitor blood pressure)." This allows any CMS-certified dialysis facility to provide self-care to meet the level of care that a patient decides to undertake.

OVERNIGHT PD CENTERS

Dialysis facilities could also be used as an overnight PD center for patients to receive IPD via cyclers. This could address housing restriction issues such as space and lack of proper physical environment (such as water/sewer sources, climate control, electrical supplies).

HOME TRAINING CENTERS

The facilities can be converted to home training centers but would require remodeling to comply with the regulations for a home training area. The standard hemodialysis treatment floor is not set up properly to conduct home training – PD or hemodialysis.

Impact on Nephrologists and Transplant Surgeons

Following Trump's executive order, the Centers for Medicare and Medicaid Services (CMS) proposed five new payment models for providers treating patients with chronic kidney disease.

To encourage greater use of home dialysis and kidney transplantation, **CMS is proposing the End-Stage Renal Disease Treatment Choices Model.** This model would adjust certain Medicare payments to facilities and clinicians randomly selected for participation. Payments would be adjusted upward or downward based on a facility or clinician's home dialysis and transplant rates. The model would also risk adjust the home dialysis and transplant rates used for the performance payment adjustments, which would not penalize those providers with sicker patients. The adjustments would begin on January 1, 2020, and end on June 30, 2026.

These models allow the transplant center, dialysis facilities and nephrologists to collaborate and share profit/risk. As a result, the transplant surgeon and transplant nephrologist will need to closely coordinate with the local referring nephrologist post-transplant, and the patients may return earlier to the community nephrologist for post-transplant follow-up. Currently, these relationships are more referral only and not tied to CMS payments as directly as the proposed new models.

Artificial Kidney Development

There were **19,360 kidney transplants in 2018,** according to UNOS. However, there are around **93,000 people on the kidney transplant waitlist,** and 5% of these patients die each year waiting for a kidney.

Part of the Trump administration's rule is to increase kidney donation, which it plans to do by removing financial disincentives for living organ donation.

KIDNEYX

HHS and the American Society of Nephrology have partnered to accelerate the development of drugs, devices, biologics and other therapies across the spectrum of kidney care.

Phase 1 of the project — which announced winners in April 2019 — focused on the development of artificial kidney devices. Each of **the 15 winners of Phase 1** received $75,000 to create their solutions. **Phase 2 of KidneyX,** "challenges participants to build and test prototype solutions, or components of solutions, that can replicate normal kidney functions or improve dialysis access." Three winners will be awarded $500,000. Submissions are due by January 31, 2020.

Conclusion

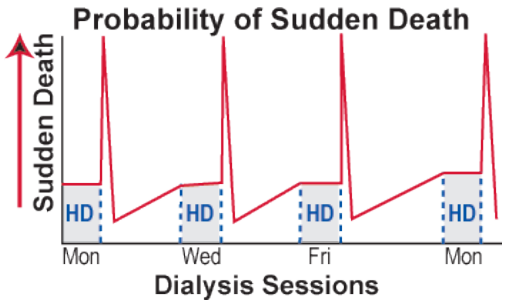
Advancing American Kidney Health has the potential to shake up kidney disease treatment in the U.S. By staying on top of the latest developments, you can ensure you have the knowledge you need to provide your patients with the best treatment options while protecting your clinics and staff.

Better Hemodialysis Patient Care

THROUGH NON-INVASIVE ON THE SPOT CARDIAC FUNCTION ASSESSMENT

Cardiovascular Disease — An ESRD Epidemic

There is an epidemic among hemodialysis patients. It is the leading cause of death and morbidity in patients with end-stage renal disease (ESRD)[2-3]. It accounts for half of dialysis patient deaths and a third of patient hospitalizations.[4] And it is not being monitored very well.



"35% of deaths occurred in the first 12-hour interval ... 27% of these deaths occurred during dialysis and 33% occurred in the first hour after the dialysis treatment."[6]

Cardiovascular disease (CVD) is wreaking havoc on ESRD patients—both during their hemodialysis treatments and during their time away from clinics.

"In addition, cardiovascular collapse is a major cause of complications during hemodialysis treatments."[5] Congestive heart failure (CHF) in ESRD patients results from cardiac overload, anemia, severe hypertension and cardiac dysfunction. CVD mortality rates are approximately 30 times that of the general population,[4] and in adolescents, CVD mortality rates are over 1,000 times that of their age-related peers.[28]

Patients who do not feel well at the end of a dialysis session are subject to an unidentified decrease in Cardiac Index (CI) to critical ICU levels of <2 L/min/m².

As an AV fistula steals flow from an already limited systemic circulation, low CI can become a major contributor to decreased myocardial perfusion leading to sudden death.

Hemodialysis — A Stress Test for Cardiac Function

> *Hemodynamic stability is threatened and often severely compromised by hemodialysis largely because of the obligate fluid removal during a short time span.*[7]

Thomas Depner, MD, underscores the importance of testing cardiac function during hemodialysis.[7,8] He notes that the rapid removal of large volumes of fluid during hemodialysis severely tests the limits of a patient's cardiac function. Just as a treadmill stress test gauges a heart's response to exercise, cardiac output measurements during hemodialysis monitor a heart's response to fluid removal during the dialysis treatment. Because cardiovascular parameters can change dramatically during dialysis, multiple cardiac measurements are advised during a dialysis session in order to assess a patient's clinical condition.[8]

Cardiac Output and Access Flow

Although extensively documented in the literature, the AV access is also often overlooked as a source of cardiac dysfunction. By bypassing the customary arteriole/capillary beds and establishing a direct high flow connection between the arterial and venous systems, an AV access creates a drop in peripheral arterial resistance which significantly affects blood flow. In order to maintain blood pressure and improve cardiac output, the body compensates for this precipitous drop in resistance by increasing heart rate and stroke volume.[3,9,10] This phenomena was first observed in World War II soldiers with trauma-induced arteriovenous fistulas.[3] Iwashima et al reported a 15% increase in cardiac output by the seventh day after arteriovenous fistula creation.[10] This increased cardiac workload can lead to an increase in size of the left ventricle (left ventricular hypertrophy).[9,10]

"An Easily Overlooked Diagnosis"

In 1995, Engelberts and Tordoir et al (Maastricht University, the Netherlands) reported a case where excessive shunting in a hemodialysis access fistula led to high-output cardiac failure. They termed it "an easily overlooked diagnosis." Following surgical closure of the fistula, the patient's condition improved, and signs of congestive heart failure subsided."[7] In 1998, PR Young Jr. et al (Bowman Gray School of Medicine, Wake Forest University) reported two renal transplant patients who developed high-output cardiac failure from brachiocephalic fistulas. Successful transplantation, coupled with fistula ligation, resolved the cardiac complications.[8] Additional reports[30-32] cemented the relationship between high-volume AV access flows and cardiac complications.

Access Flow - Cardiac Output (AF/CO) Ratio

MacRae et al (University of Calgary, Canada) reported the high output cardiac failure associated with high flow AVFs (> 1.5 L/min), particularly in men with upper arm fistulas and previous access surgeries.[2,4,5] In her 2006 comprehensive review, "The Cardiovascular Effects of Arteriovenous Fistulas in Chronic Kidney Disease: A Cause for Concern?", MacRae documents the evidence, to date, on the subject.[2] She emphasizes that the ratio between access flow and cardiac output is an important clinical indicator and notes that the average flow in an upper arm fistula is 1.13 to 1.72 L/min. In the same study, 15% of patients were found to have flows of over 2 L/min. Access flow that exceeds 25% of cardiac output indicates a potential cardiac problem. In most cases, high output cardiac failure was associated with a access flow to cardiac output ratio of more than 40 percent.[10] MacRae recommends that hemodialysis patents be screened for potential high output cardiac failure using a Qa/CO ratio and patients with a Qa/CO ratio of more than 30 percent undergo further testing.[10]

Italian Study Sets 2L/min AVF Flow Cut-off Value

In 2008, Basile et al (Miulli General Hospital, Acquaviva delle Fonti, Italy) published a study of 96 patients with AV fistulas and cardiac failure.[24] The study showed that upper arm AVFs are associated with an increased risk of high output cardiac failure. It was the first published study with a high predictive power for AV fistula flows greater or equal to 2.0 L/min to result in high-output cardiac failure. In this landmark study, both AV access flow and cardiac output were measured using the Transonic Hemodialysis Monitor.

"A high flow AV access can produce life-threatening cardiac complications. The volume flow level that will induce high-output failure or extremity ischemia will vary with each patient, based on co-morbidities, especially the degree of cardiac disease and peripheral arterial disease. For patients at risk based on such pre-existing conditions, which can be a majority of patients in a given hemodialysis population, the widespread consensus (evidence-based) is that patients with access flows of 2L/min or higher should be tested and followed for these complications--and have a flow-reduction procedure performed at the earliest signs of cardiac complications or extremity ischemia.

Unfortunately, with the high prevalence of cardiac disease in the HD population, an insidious and silent access flow as a major cause or contributor to a potentially deadly cardiac complication, is often overlooked. Therefore, it is critically important for the practitioner to be aware of the relationship between access flow and cardiac failure, since many of these high-flow patients will have morbidity and mortality that otherwise could have been avoided."[39]

Lawrence Spergel MD, FACS, founding father and clinical director of the Fistula First Breakthrough Initiative

Studies/Reviews Highlight High AVF - CO Link

In the 2013 October issue of Clinical Transplant, Schier et al (Innsbruck University, Austria) reported the results of a 2005-2010 retrospective study of kidney-transplant recipients. Twenty-five percent of the recipients (29 of 113) needed an AV fistula closure, mostly due to cardiac failure symptoms.[25] Stern et al from UNC Kidney Center's Division of Nephrology and Hypertension, in Chapel Hill, NC describes how an increase in preload can lead to increased cardiac output when a large proportion of arterial blood is shunted from the left-sided circulation to the right-sided circulation via the fistula. Patients may present with the usual signs of high-output heart failure including tachycardia, elevated pulse pressure, hyperkinetic precordium, and jugular venous distension. The nephrologist is then faced with the dilemma of preventing progression of heart failure at the expense of losing a vascular access. The authors conclude that treatment should be directed at correcting the underlying problem by surgical banding or ligation of the fistula.[26]

In her 2012 Seminars in Nephrology article, "High-output Heart Failure: How to Define It, When to Treat It, and How to Treat It," Wasse et al (Emory University) succinctly outlines the problem.[27] Dr. Wasse describes the mechanisms by which a dialysis AV access may promote the development of high-output cardiac failure, the risk factors for and diagnosis of high-output heart failure, and recommends management strategies for patients with high-output heart failure. The literature addressing the various types of cardiac complications (congestive heart failure, left ventricular hypertrophy, coronary artery disease, right ventricular dysfunction, valvular heart disease, aortic stenosis) of AV fistulas in patients with end-stage renal disease has been most recently reviewed by Dr. Alkhouli and colleagues in their 2015 publication in Nefrologia.[28]

EXCERPT: CARDIAC COMPLICATIONS OF ARTERIOVENOUS FISTULAS IN PATIENTS WITH END-STAGE RENAL DISEASE

Alkhouli M et al,, Nefrologia. 2015 May-Jun;35(3):234-45[28]

"Despite their association with a lower mortality, AVFs have significant effects on cardiac functions predominantly related to the increase in preload and cardiac output (CO). Patients with end stage renal disease (ESRD) requiring dialysis almost invariably have volume overload due to water and salt retention. They also have pressure load due to arterial sclerosis and hypertension, and increased CO secondary to chronic anemia. In addition, many hemodialysis patients have significant pre-existing myocardial, valvular or coronary heart disease. It is, therefore, often difficult to tease out the exact contribution of an AVF to cardiac dysfunction in hemodialysis patients. Nevertheless, worsening in cardiac functions soon after AVF creation has been observed favoring a causative effect of the AVF on certain cardiac functions. Current literature suggests that the creation of an AVF can cause or exacerbate the following conditions: congestive heart failure, left ventricular hypertrophy, pulmonary hypertension, right ventricular dysfunction, coronary artery disease, and valvular dysfunction."

Studies/Reviews Highlight the Benefits of Reducing AVF Flow

In a study in Hemodialysis International, researchers studied the effects of reducing flow in high-flow AV accesses to between 600 mL/min to 1200 mL/min.

They discovered patients who underwent banding of their inflow at the anastomosis with perioperative access flow measurement after experiencing acute congestive heart failure (CHF) had a statistically significant decrease in "cardiac output (pre 7.06 L/minutes, post 56.47 L/minutes P 0.03), pulmonary systolic pressure (pre 54 mmHg, post 44 mmHg P 5 0.02), left ventricular mass index (LVMI) (pre 130 g/m2 , post 125 g/ m2 P 0.006) and need for rehospitalization for CHF decompensation."

EXCERPT: FLOW REDUCTION IN HIGH-FLOW ARTERIOVENOUS FISTULAS IMPROVE CARDIOVASCULAR PARAMETERS AND DECREASES NEED FOR HOSPITALIZATION

Balamuthusamy, S. et al. Hemodialysis International 2016; 20:362–368

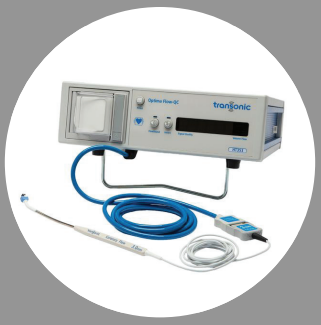
Dynamic changes in tricuspid annular plane systolic excursion and left ventricular end diastolic pressure occurred with single hemodialysis sessions in patients dialyzing through a fistula as opposed to a tunneled dialysis catheter.12 The changes in cardiovascular hemodynamic variables were observed irrespective of the uremic milieu seen after ligation of the AV access in kidney transplant patients.13 The hemodynamic alterations could be due to the direct hemodynamic effects of the fistula in addition to systemic endocrine and neurohumoral changes. Alterations in pulmonary vascular resistance, left ventricular geometry and right ventricular function have been demonstrated in observational studies in patients with an AV access. Some of the cardiovascular changes observed in hemodialysis patients with an AV access could be influenced by other factors including hypertension, excessive fluid retention, dialysis adequacy and duration, hemoglobin levels, and vascular calcification. We have included these important clinical variables while evaluating the effects of access flow reduction on cardiovascular function and rehospitalization.

When to Intervene

Balamuthusamy, S. et al. recommend:
"Monitoring patients with flow greater than 2 L/minute either with the NYHA Classification or the Canadian subjective cardiovascular assessment on a periodic basis and correlate those findings with changes in access flow. Patients with recurrent admissions or worsening NYHA class could benefit from flow reduction. However, the occurrence of irreversible cardiac decompensation might be too late to reverse the distorted cardiac geometry with flow reduction.[14] Bimodal 2D echocardiogram could be a useful tool to assess the cardiac geometry in patients with a high flow fistula. Patients with moderate to severe valvular diseases, moderate to severe pulmonary hypertension and morphological changes progressing toward biventricular dilation cardiomyopathy may benefit from pre-emptive access flow reduction.[6]"

How to Intervene

Balamuthusamy, S. et al. recommend:
"Access flow reduction can be accomplished by either distalizing or banding the inflow. Alternate inflow conduits can be facilitated by ligating the existing anastomosis and creating inflow through a neo-anastomosis using a vein graft or a synthetic graft at the distal high-resistance, low-flow radial artery Revascularization Using Distal Inflow (RUDI). An alternate method is ligation of the artery distal to the anastomosis and revascularizing the flow to the distal arm through a synthetic graft. Both these methods have their merits and disadvantages. Distalization of the inflow from a low-flow, high-resistance source to a dilated low-resistance fistula may not be able to accomplish adequate flow for dialysis. There have been increased episodes of access clotting reported with these procedures. Banding the inflow at anastomosis based on the diameter of the distal artery and intraoperative access flow monitoring would be a safe and effective modality to decrease flow."



A Surgical Banding Case Report

EFFECT OF SURGICAL BANDING OF A HIGH-FLOW FISTULA ON ACCESS FLOW AND CARDIAC OUTPUT: INTRAOPERATIVE AND LONG-TERM MEASUREMENTS

Murray, B., et al American Journal of Kidney Diseases, 2004 Volume 44, Issue 6, Pages 1090–1096

The authors describe a case where a patient's fistula blood flow was monitored before, during, and up to 12 months after a banding procedure for high-output cardiac state, and how intraoperative measurement of access flow was useful in confirming an adequate degree of fistula constriction, and postoperative monitoring of both access flow and CO not only confirmed the adequacy of the procedure but was also useful in determining its long-term efficacy.

READ THE FULL CASE REPORT HERE

Proactive Cardiac Function Assessment During Hemodialysis

It is therefore incumbent upon the nephrologist to order periodic cardiac function tests, and track the results along with its associated vascular access flow rates. While access flow remains fairly constant during a hemodialysis treatment, cardiac output decreases an average of 20% during the treatment causing less blood flow to be available to sustain the body's vital functions. A healthy body will respond to this by increasing peripheral resistance to sustain the blood supply to the heart and brain. Other considerations include:

- The site of a vascular access affects average flow values. Upper arm sites typically have higher flows than lower arm sites.
- Patients with initial high flow fistulas are at greater risk for cardiovascular problems. A fistula may "over-mature" and present a flow over 2 L/min.
- Autologous fistulas tend to remain sufficiently patent to sustain dialysis at lower flows than do prosthetic grafts.
- A straight upper arm prosthetic graft may initially exhibit an overly high flow. Graft flow tends to decrease over time, so banding a prosthetic graft is not advised. Access flow and cardiac function of these patients should be monitored monthly to ensure that access flow drops before cardiac complications arise.

> *"The ability to monitor cardiac output is one of the important cornerstones of hemodynamic assessment …in particular in patients with pre-existing cardiovascular comorbidities."*
> *Tucker T et al*[11]

While many clinicians rely on BP changes to assess CI, researchers Stefanie Haag, et al, found that BP changes do not adequately and sensitively reflect changes in CI, as previously reported. Haag, et al, assert the only way to fill this gap is through ultrasound dilution measurement.

Read the study: Systemic haemodynamics in haemodialysis: intradialytic changes and prognostic significance, Nephrology Dialysis Transplantation (2018) 1–9.

The Cardiovascular Effects of Arteriovenous Fistulas in Chronic Kidney Disease: A Cause for Concern

Immediate hemodynamic effects of AVF creation	• Increase in cardiac output (10-20%). • Increase in sympathetic nervous system activity (increasing contractility). • Increase in stroke volume and heart rate. • Decrease in peripheral resistance.
Hemodynamic changes within one week of AVF creation	• Increase in circulating blood volume resulting in increased left atrial, inferior vena cava, and left ventricle end-diastolic volume (LVEDV). • Increase in neuro-hormones: vasodilator atrial natriuretic peptide (ANP) and brain natriuretic peptide (BNP) implying atrial and ventricular filling pressure are increased. • Decrease in plasma renin and aldosterone levels. • Decrease in systemic vascular resistance and systolic/diastolic blood pressure.
Long-term consequences of AVF creation	**Left Ventricular Hypertrophy (LVH)** • An adaptive response to increased cardiac workload caused by volume or pressure overload.
	High-Output Cardiac Failure • High-flow AVF patients have a greater risk of developing CHF and greater increase in LVEDV. • AVFs in HD patients may contribute to the development of heart failure. • Left ventricle enlargement at the start of HD is very common and progressive left ventricle dilation with hypertrophy continues over time. Most of the left ventricle growth occurs during the first year of dialysis.
	Exacerbation of Coronary Ischemia • AVF placement is associated with increased myocardial O2 demand that may not be met, especially in patients with established coronary artery disease (CAD) or left ventricle hypertrophy (LVH). • Increased O2 consumption may have clinical manifestations in dialysis patients who have had CABG. A decrease in coronary perfusion that occurred with the onset of HD was demonstrated by the reduction in graft flow and reversible hypokinesis of the anterior left ventricle wall. • High-flow AVFs with associated high cardiac output may increase O2 demand.
	Central Vein Stenosis • The endothelium plays an active role in vascular remodeling by secreting vasoactive substances and growth factors in response to alterations in flow and shear stress. • Increased blood flow due to AVF creation alters the shear stress on the endothelium and promotes production of substances like transforming growth factor (TGF-ß) and NO which dilate the vessel lumen. • A majority of central vein stenosis occurs at the junction of the cephalic and subclavian veins. There was a high correlation between the location of a central vein stenosis and ipsilateral AVF. It suggests that altered flow hemodynamics due to a fistula may result in endothelial damage and vascular remodeling, leading to stenosis.

MacRae JM et al, Seminar in Dialysis 2006; 19:349-352.

Conclusions

- AVFs are superior to catheters and grafts due to fewer thrombogenic and infectious complications.
- A thorough cardiac assessment should be performed in patients with CAD prior to placing an AVF.
- Regular careful evaluations are necessary in patients with cardiac disease and AVFs.
- Patients with high flow fistulas (flow greater than 2L/min) and increasing LVEDV are recommended to have a flow reduction procedure on their AVF.
- Patients with preexisting severe ischemic heart disease should avoid AVF placement if the underlying ischemia cannot be treated.

The Quality of Cardiovascular Disease Care for Adolescents with Kidney Disease: *A Midwest Pediatric Nephrology Consortium Study.*

Background	Cardiovascular disease (CVD) is the leading cause of increased mortality for adolescents with advanced kidney disease. Many patients have CVD mortality rates 1,000 times that of their age-matched peers and will die prematurely in early adulthood. Guidelines call for screening for cardiovascular risk factors in this population of patients.
Objective	To ascertain if the quality of preventive cardiovascular care may impact long-term outcomes for these patients.
Methods	• Records of 196 consecutive adolescents from seven American centers and one Canadian pediatric center with pre-dialysis chronic kidney disease, on dialysis or with a kidney transplant, who transferred to adult-focused providers were reviewed. • Cardiovascular risk assessment and therapy within and across centers were compared. • Predictors of care were assessed using multilevel models.
Results	• Overall, 58% of five recommended cardiovascular risk assessments (family history of CVD, smoking status, lipid profile, physical activity, echocardiography for patients with a history of hypertension) were documented. • Documented most frequently was smoking status (74%); an echocardiogram in patients with a history of hypertension (70%); family CVD history (53%); fasting lipid profiles and physical activity (47%) respectively. • Only 20 of the 196 total patients (10%) received 100% of all indicated cardiovascular risk factor assessments. • Recommended therapy for six modifiable cardiovascular risk factors was documented 57% of the time. • Transfer after 2006 and kidney transplant status were also associated with increased cardiovascular risk assessment.
Conclusions	• Adolescents with kidney disease receive suboptimal preventive cardiovascular care, that may contribute to their high risk of future cardiovascular mortality. • A opportunity exists to improve outcomes for children with kidney disease by improving the reliability of preventive care that may include formal transition programs.

Hooper DK et al, Pediatr Nephrol 2013; 28(6): 939-49.29

Cardiac Function Assessment

Methodology

Cardiac output is the volume of blood being pumped by the heart in one minute. An average resting cardiac output is 5.6 L/min for a human male and 4.9 L/min for a female.[1]

> *It is astonishing that no one has arrived at the following obvious method by which the amount of blood ejected by the ventricle of the heart with each systole may be determined directly... Adolf Fick, 1870.*

Adolf Fick introduced a method to measure an animal's cardiac output (CO) from arterial and venous blood oxygen measurements. His principle later formed the foundation of Stewart's indicator-dilution technology. In 1928, Stewart's equation was modified by Hamilton who described the bell-shape of a classic dilution curve (Fig. 1).

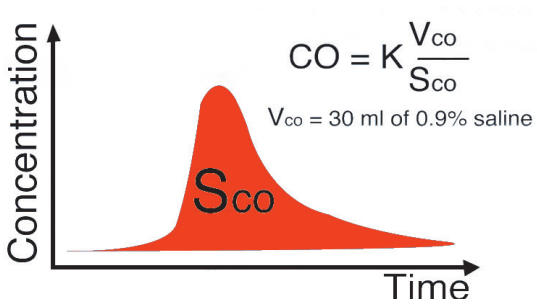


Fig. 1: Time concentration curve showing saline indicator dilution curve. CO is inversely related to the average dilution indicator concentration and the total time of indicator passage or

$$CO = \frac{\text{the amount of indicator injected}}{\text{area of the dilution curve}}$$

A variety of indicators have been used with this time-tested technology. All require that three criteria be met. They are:

1. **Injection Phase:** a known indicator is introduced into the circulatory system.
2. **Mixing/dilution Phase:** the indicator mixes with the blood.
3. **Detection Phase:** The indicator concentration is measured downstream from its introduction.

Ultrasound dilution methodology, pioneered by Nikolai Krivistki PhD, DSc, uses body temperature saline, an innocuous indicator, that is injected into a patient's peripheral vascular access during the dialysis treatment. Injected into the venous blood line, the indicator travels through the heart and lungs and returns via the arterial system where a Flow/dilution Sensor records the diluted blood concentration (Fig. 2). Classic Stewart-Hamilton equations are used to calculate cardiac function and central hemodynamic parameters including Cardiac Output (CO), Cardiac Index (CI), Total Ejection Fraction (TEF), Access Flow to Cardiac Output Ratio (AF/CO) and six additional parameters.

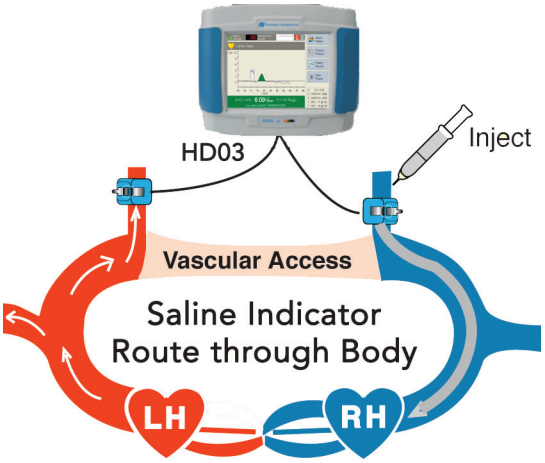


Fig. 2: Saline Indicator Route: Body temperature saline is injected into the venous line, travels through the heart and lungs and returns via the arterial system where a flow/dilution sensor records the diluted concentration.

Flow-QC® Cardiac Function Assessment

Transonic Flow-QC® Cardiac Function Assessment with ultrasound indicator dilution technology provides a way to integrate cardiac function studies into a hemodialysis clinic's treatment protocol in order to forestall the devastating consequences of CVD.

Transonic Flow-QC cardiac function measurements help diagnose cardiac overload in ESRD patients.[1,11] When access flows measured during the dialysis session are unusually high (>2 L/min), cardiac overload can be suspected. A follow-up Flow-QC cardiac output measurement will verify whether the heart is stressed.

Cardiac output measurements during hemodialysis combined with access flow identify:

- **A.** Prolonged high access flow to cardiac output ratio that stresses the heart and can result in cardiomegaly and heart failure.
- **B.** Dangerously low cardiac index that places patients at high risk for cardiovascular complications and failure.
- **C.** Dramatic decreases of cardiac index during hemodialysis due to inaccurate dry weight estimation and/or inadequate medication.
- **D.** Dangerous decrease in central blood volume during hemodialysis that may portend hypotensive episodes.

Flow-QC® Cardiac Function Parameters

HD Cardiac Parameters	Typical Range (Observed in 70% of data)	Atypical Range*	Clinical Relevance	Interpretation & Recommendations
CARDIAC OUTPUT (CO) L/MIN	5 - 8 L/min	< 2 L/min > 10 L/min	Increased risk for cardiovascular complications and failure.	CO varies by patient parameters and is used to calculate AF/CO ratio. CO alone should not be used for guidance.
CARDIAC INDEX (CI) L/MIN/M²	2.2 - 3.8 L/min/m²	< 2.0 L/min/m²	If observed at the beginning of the session: indicates significant deterioration of CO function.	Refer to cardiologist for full study. Check for chronic hypoxia.
			A 20-30% drop in CI during the session: indicates inadequate dry weight estimation and/or effects of medication.	The dry weight and medications should be clinically evaluated and updated if needed and these measurements should be repeated at the beginning and end of session..
		> 4 L/min/m²	In approximately 50% of cases, high CI is associated with increased fistula flow. In other cases, high CI is associated with fluid overload or low hematocrit levels.	Determine reason for increased CI. Implement proper treatment: • AV access evaluation intervention; • Adjustment to the dialysis prescription; • Adjustment to anemia management.
STROKE VOLUME INDEX (SVI) ML/M²	32 - 56 mL/m²	< 20 mL/m²	Usually indicates low preload (hypovolemic status)	Suggest SVI parameters be included in the clinical evaluation.
		> 60 mL/m²	Usually associated with high fistula flow.	
TOTAL EJECTION FRACTION (TEF) %**	40 - 76 %	< 40 %	Effective heart performance is decreased. Low value may increase mortality.	Determine if a referral to a cardiologist for additional clinical assessment is appropriate.
SYSTEMIC VASCULAR RESISTANCE (SVRI) DYNES·SEC/CM⁵/M²	1900 - 3200 dynes.sec/cm⁵/m²		In non-hemodialysis adult patients, expected value is 2000-2400.	Currently, there are no clear guidelines for the expected SVRI. SVRI in dialysis patients may be higher than in the non-hemodialysis population.
TOTAL END DIASTOLIC VOLUME INDEX (TEDVI) ML/KG	6 - 11 mL/kg	> 11 mL/kg	Increased TEDVI potentially indicates cardiomegaly and increased mortality.	Determine if a referral to cardiologist for additional assessment is appropriate.

Continued on next page →

Flow-QC® Cardiac Function Parameters (continued)

HD Cardiac Parameters	Typical Range (Observed in 70% of data)	Atypical Range*	Clinical Relevance	Interpretation & Recommendations
CENTRAL BLOOD VOLUME INDEX (CBVI) ML/KG	13 - 23 mL/kg	< 14 mL/kg	If measurement of < 14 mL/kg is taken at the beginning of the session, the patient started on the hypovolemic side. If patient is on the lower end at the end of session, this is less of an issue.	Special care should be taken during HD session to avoid hypotensive episode.
		> 25 mL/kg	If patient came to session with >25 mL/kg, there is significant fluid overload. If patient ends with >25 mL/kg, insufficient fluid was removed during session.	Assess patient for fluid volume overload. Evaluate if any adjustment for the Dry Weight/ Target Weight is indicated. Evaluate if the patient may need additional education/assistance with the fluid restriction included in their diet prescriptions. Repeat study.
ACTIVE CIRCULATION VOLUME INDEX (ACVI) ML/KG	40 - 70 mL/kg	< 45 mL/kg	If measurement of < 45 mL/kg is taken at the beginning of the session, the patient started on the hypovolemic side. If patient is on the lower end at the end of session, this is less of an issue.	Special care should be taken during HD session to avoid hypotensive episode.
		> 65 mL/kg	If patient came to the session with > 65 mL/kg, there is significant fluid overload. If patient ends with > 65 mL/kg, insufficient fluid was removed during session.	Assess the patient for fluid volume overload. Evaluate if any adjustment for the Dry Weight/Target Weight is indicated. Evaluate if the patient may need additional education/assistance with the fluid restriction included in their diet prescriptions. Repeat study.
OXYGEN DELIVERY INDEX (ODI) ML O_2/ MIN/M^2	420 - 500 mL O_2/min/m^2	< 400 mL O_2/min/m^2	Under O2 delivery may be related to low hemoglobin, low CI or high fistula flow.	Refer to nephrologist for evaluation to determine source of issue.
ACCESS FLOW / CARDIAC OUTPUT (AF/ CO) %	15 - 25 %	> 25 - 30 %	Increased risk for cardiovascular complications and failure. High flow fistulas can lead to high output cardiac failure.	For high fistula flows, repeat AF and CO at the end of the session to re-evaluate ratio. Consider evaluating patient for high output cardiac failure. Consider reducing AF by banding or other surgical procedure.

** Suggests additional clinical evaluation for clinical relevance.*

*** Each chamber of the heart has its own Ejection Fraction. Total Ejection Fraction is the aggregate measures of all 4 chambers and is not interchangeable with EF.*

Measuring Cardiac Function

Cardiac function measurements with a Transonic® HD03 Flow-QC® Hemodialysis Monitor require:

- DTM or PMM that has the Cardiac Output Feature
- Flow-QC Clear Advantage Tubing Set with a dedicated injection port for saline indicator injections into the venous blood line
- 30-mL syringes filled with saline warmed to body temperature

DISPOSABLE FLOW-QC® CLEAR ADVANTAGE TUBING SET

A Flow-QC Clear Advantage Tubing Set provides a safe injection port for a rapid 4 -7 second injection of a cardiac output saline bolus. The tubing set provides a consistent measurement environment. The ultrasonic and mechanical properties of these tubing sets are controlled to guarantee measurement accuracy, eliminate measurement variability from blood line brands, and reduce the need for periodic sensor calibration.

The Flow-QC Clear Advantage Tubing Set is placed in the hemodialysis circuit between the bloodline tubing and the venous and arterial needle tubing with the Flow/dilution Sensors positioned on the Flow-QC Clear Advantage Tubing. A bolus injection at another site, such as the bubble trap, would take too long to pass through the sensor and the software program may not be able to separate the timing of the first pass of the saline bolus from subsequent passes.

To measure cardiac output and related parameters, fill a 30 mL syringe with 30 mL of saline warmed to body temperature. Insert Flow-QC® Clear Advantage® tubing segment into the hemodialysis circuit as shown (Fig. 3) and then prime tubing.

Attach the arterial & venous Flow-QC Clear Advantage tubing to the needle tubing (c) in normal line position with the Flow/dilution Sensors positioned in the middle of the Flow-QC Clear Advantage tubing lines with the arrows on the sensors each pointed in the direction of flow.

With a Cardiac Output Data Transfer Module (DTM-CO) inserted in the HD03 Monitor, press the [Measure Patient] icon. Select the Flow-QC Tubing icon on the [Select Tubing] screen. Then press the [Cardiac Output] button to initiate the cardiac output measurement sequence. Enter parameters in the required fields and follow on-screen directions for the 6-7 second injection of 30 mL warmed saline. Measurement results including a CO dilution curve, calculated CO, CI and CBV values will display on the monitor. Notes:

- If two measurements are within 15% of each other, a third measurement is not needed. If a Repeat Measurement message displays, repeat injection.
- CO can be measured in patients with access flow and no access recirculation. CO cannot be measured in patients with a central venous catheter.

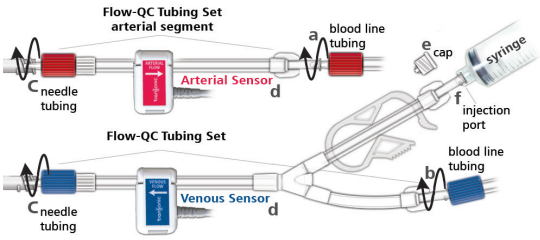


Fig. 3: The red-banded end of the arterial segment is connected to the male end of the arterial bloodline and the blue-banded branch of the Y end is connected to the male luer-lock connector on the venous bloodline.

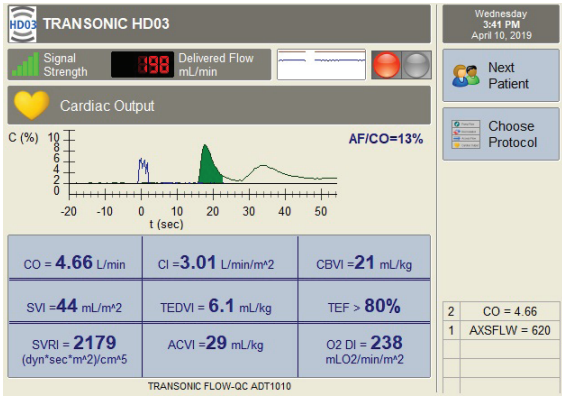


Fig. 4: Monitor display of measurement results.

Central Hemodynamic Profiling (CHP)

Central Hemodynamic Profiling identifies low CI and offers the physician the opportunity to improve CI by adjusting dry weight medication and length of dialysis.[1,11]

Effective cardiac function management depends on a routine screening program such as Central Hemodynamic Profiling (Fig. 5) that identifies patients who leave hemodialysis sessions with dangerously low cardiac indices (CI ≤ 2.0), thereby increasing their risk for death, stroke or myocardial infarction. CHP is the periodic assessment of cardiac function during hemodialysis in order to track the heart's response to the stress of a dialysis treatment.

A CHP study (Flow Chart, page 18) consists of hourly cardiac output measurements throughout the hemodialysis treatment. Transonic® Flow-QC Cardiac Output software automatically calculates cardiac index. If cardiac index drops below 2 L/min/m² during treatment, the hemodialysis prescription should be reviewed and adjusted immediately.

After adjustments are made, another CHP study should be performed during the next dialysis session. If this profile is stable and in the appropriate range, the patient's cardiac status can then be monitored as usual.

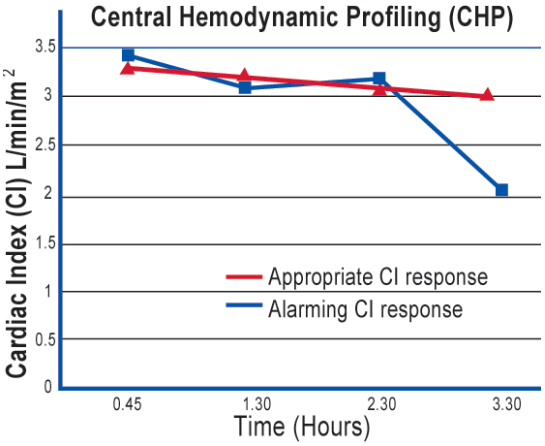


Fig. 5: Central Hemodynamic Profiling (CHP): four measurements taken during a single hemodialysis session shows Cardiac Index responses to the hemodialysis treatment. Acceptable CI results range between 2.5 - 4.2 L/min/m².[37,38]

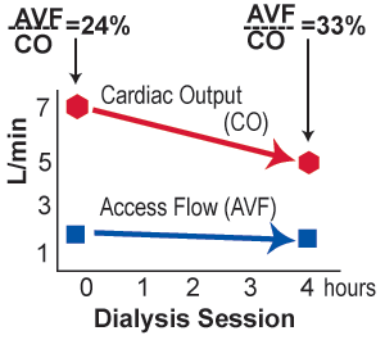


Fig. 6: One-third of CO is redirected from the systemic circulation to the AV fistula placing patients at cardiac risk.

Cardiac Function Study Protocol

CHP identifies:

- Prolonged high levels of access flow (>1,600-2,000 mL/min) that can lead to cardiomegaly and high output cardiac failure identified by an access flow to cardiac output ratio (AVF/CO) exceeding 25-30% (Fig. 6).
- Cardiac Index of <2 L/min/m².
- Dramatic 20-30% drop in cardiac output during dialysis due to inaccurate dry weight estimation and/or medication that places patients at high risk for cardiovascular complications and sudden death following the session (Figs. 6,7).

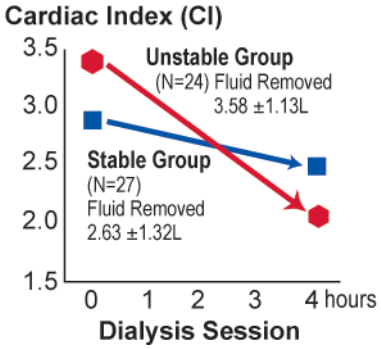


Fig. 7: Inadequate dry weight estimation increases the risk of cardiac failure.[1,11]

FLOW-QC CARDIAC FUNCTION STUDY PROGRAM

INITIAL CARDIAC STABILITY ASSESSMENT

For new patients, patients who have had interventions, and patients with suspected cardiac complications. Transonic Flow-QC Protocol begins with a Tucker Central Hemodynamic Profiling (CHP) study consisting of hourly cardiac output measurements during the hemodialysis session. If a patient is stable (CI > 2.5), the measurements serve as the first data point for the patient's cardiac function baseline.

THREE-PART BASELINE CARDIAC FUNCTION STUDY

The Baseline Cardiac Function Study established reliable average cardiac function parameters for the patient and consists of:

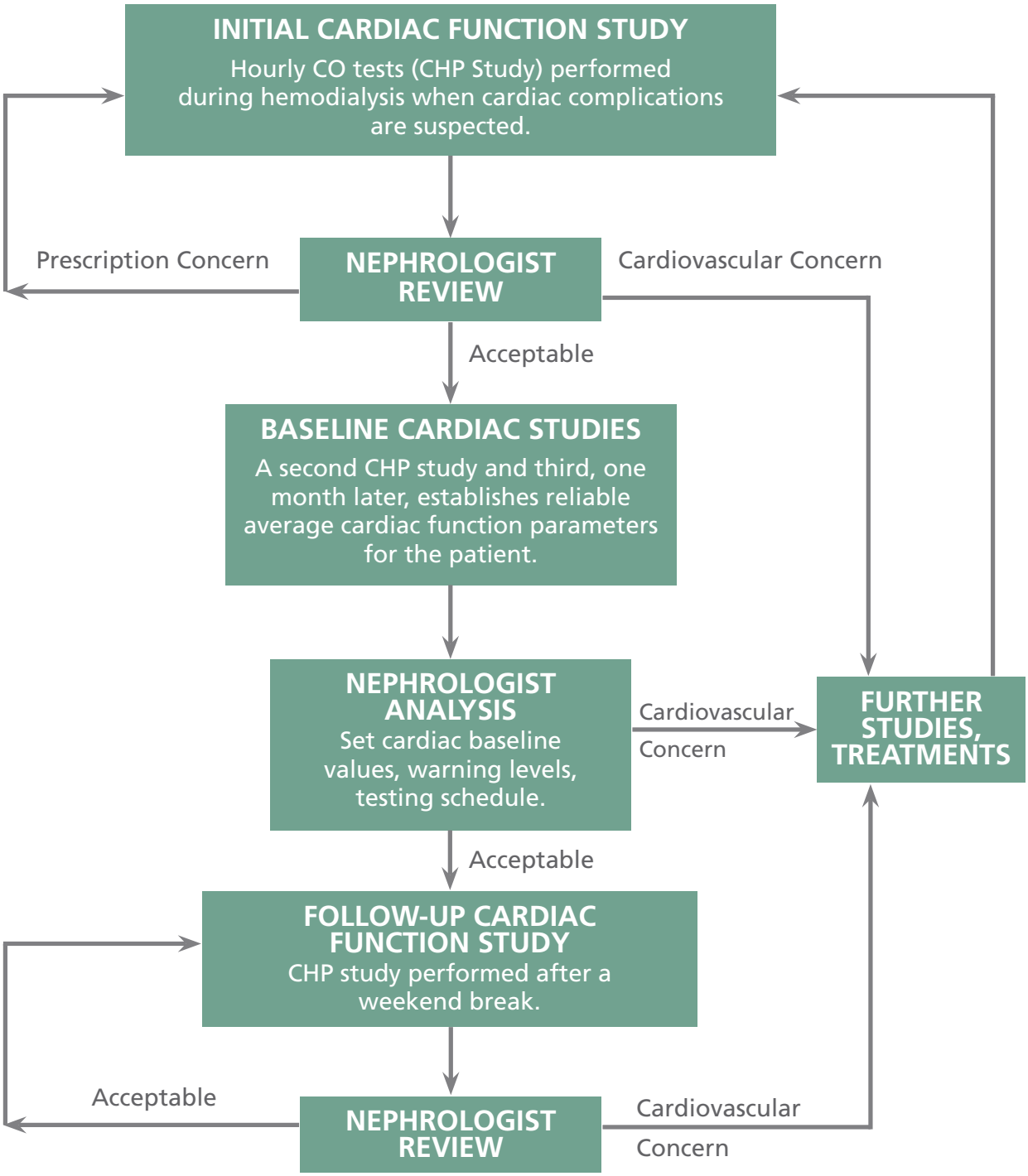
- **The first baseline CHP study performed on a stable patient (see above).**
- **A second CHP study performed shortly after the first. (One baseline study should follow a two-day dialysis break, another, after a three-day break.)**
- **A third CHP study one month later, after a weekend dialysis break, to confirm a patient's stability and serve as the third data point for the patient's cardiac function baseline.**

The nephrologist reviews the baseline study results, assesses the patient's status and prescribes a follow-up monitoring program.

FOLLOW-UP CARDIAC STUDIES

Follow-up studies serve to monitor any progression of cardiovascular disease. A follow-up study consists of periodic CHP, preferably after a weekend break. The Flow-QC Protocol recommends quarterly testing for ESRD patients whose cardiovascular condition is stable and more frequent testing for patients with cardiovascular complications.

Cardiac Function Study Protocol cont.



Cardiac Function Case Studies

High Access Flow & Potential Cardiac Overload

A patient complaining of chest pains had 3630 mL/min AV fistula flow (Fig. 8), which prompted a CO measurement. CO was 10.8 L/min (Fig. 9). The vascular access was briefly occluded with a finger, and the patient's pulse rate dropped from 112 to 88 beats per min. An X-ray identified cardiomegaly. The vascular access was banded. Following banding, access flow measured 1700 mL/min and CO dropped to 7-8 L/min. The patient exhibited fewer post-dialysis hypotensive episodes, his dry weight decreased, his chest X-ray cleared and he reported significant improvement in his previous symptoms.

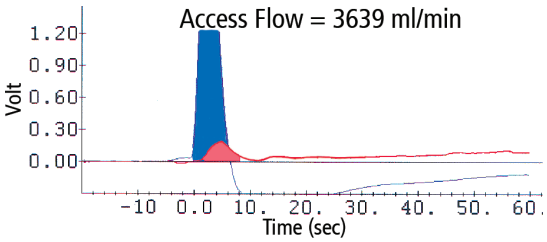


Fig. 8: Access flow measured over 3.6 L/min which prompted a CO measurement.

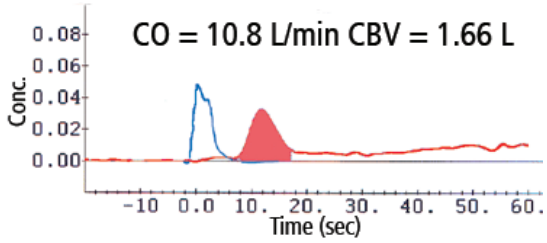


Fig. 9: Access flow measured over 3.6 L/min which prompted a CO measurement.

Deterioration of Cardiac Output & Cardiac Index during Hemodialysis

Flow-QC® Cardiac Function screening commenced 40 minutes into the hemodialysis session for a patient with ischemic heart disease. The first CO measurement was 4.3 L/min with a CI of 2.5 (Fig. 10). When the test was repeated two hours later, the patient's CO had dropped to 2.7 L/min and his CI was 1.6. The nephrologist was alerted, the patient's hemodialysis prescription was adjusted, and his cardiac condition was closely monitored.

Case studies courtesy of Dr. T.A. Depner, University of CA at Davis

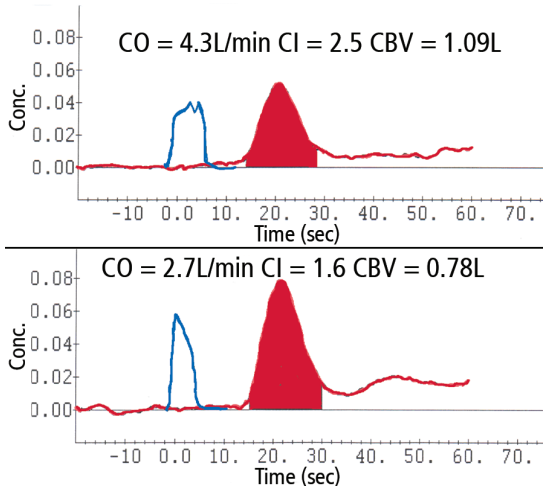


Fig. 10: Flow-QC® software screens showing deterioration of cardiac function during the course of the hemodialysis session.

Conclusion

Your hemodialysis patients do not have to be at risk for CVD or other cardiac episodes once they leave their dialysis sessions. To provide the best patient care, cardiac function screening should be added to hemodialysis treatments. The awareness of cardiac function coupled with the right technology can make providing exceptional hemodialysis patient care a reality.

START PROVIDING BETTER PATIENT CARE TODAY.
Request a demo of the technology that makes it possible.

References

1. Tucker T et al, "Unrecognized Deterioration of Cardiac Function during Hemodialysis," J Am Soc of Nephrol Abstracts 2002; 13: 213A. (Transonic Reference # HD267A).

2. Cardiovascular Disease — An ESRD Epidemic. Am J Kid Dis 1998; 32(5): Suppl 3.

3. MacRae JM et al, "The Cardiovascular Effects of Arteriovenous Fistulas in Chronic Kidney Disease: A Cause for Concern?" Sem in Dialysis 2006; 19(15): 349-352. (Transonic Reference # HD7337A)

4. Locatelli F et al, "Cardiovascular Disease in Chronic Renal Failure; the Challenge Continues," Nephrol Dial Transplant 2000; 15(Suppl 5): 69-80. (Transonic Reference # HD9643R)

5. Krivitski NM, Depner, TA, "Cardiac Output and Central Blood Volume during, Hemodialysis: Methodology," Adv Ren Replace Ther 1999; 6(3): 225-232. (Transonic Reference # HD8T)

6. Bleyer AJ et al, "The Timing and Characteristics of Sudden Death in Hemodialysis Patients" J Am Soc Nephrol 2002; 13: SU-PO737.

7. Depner TA, Krivitski NM, "Central Blood Volume: A New Criterion for Predicting Morbid Events during Hemodialysis," J Am Soc of Nephrol Abstr 1996; 7(9) 1511. (Transonic Reference # HD15A)

8. Depner TA, "Cardiac Output, Peripheral Resistance, and Central Blood Volume in Hemodialyzed Patients: Correlations with Clinical Status," Satellite Presentation ASN 1998. (Transonic Reference # VP-17)

9. MacRae JM, "Vascular Access and Cardiac Disease: Is There a Relationship? Curr Opin Nephrol Hypertens 2006; 15(6): 577-82. (Transonic Reference # HD7382A)

10. MacRae JM et al, "Arteriovenous Fistula-associated High-output Cardiac Failure: A Review of Mechanisms, "Am J Kidney Dis 2004; 43(5): 17-22. (Transonic Reference # HD408A)

11. Tucker T et al, "Central Hemodynamic Profiling (CHP) during Outpatient Hemodialysis (HD)," J Am Soc of Nephrol Abstr 2002; 13: 209A. (Transonic Reference # HD268A)

12. Krivitski NM, "Novel Method to Measure Access Flow during Hemodialysis by Ultrasound Dilution Technique," ASAIO J 1995; 41: M741-M745. (Transonic Reference # HD4T)

13. Nikiforov UV et al, "Validation of a New Method to Measure Cardiac Output during Extracorporeal Detoxification," ASAIO J 1996; 42: M903-M905. (Transonic Reference # HD15V)

14. Kislouchine VV, Dean DA, "Validation of a Novel Ultrasound Dilution Method to Measure Cardiac Output during Hemodialysis," ASAIO J 1996; 42: M906-M907. (Transonic Reference # HD16V)

15. Sands JJ et al, "Access Flow Measured during Hemodialysis," ASAIO J 1996; 42: M530-M532. (Transonic Reference # HD6A)

16. Pandeya S, Lindsay RM, "The Relationship between Cardiac Output and Access Flow during Hemodialysis," ASAIO J 1999; 135-138. (Transonic Reference # HD89A)

17. Leypoldt JK, Lindsay RM, "Hemodynamic Monitoring during Hemodialysis," Adv in Ren Replacement Ther 1999; 6: 233-242. (Transonic Reference # HD239A)

18. Hoeben H et al, "Hemodynamics in Patients with Intradialytic Hypotension Treated with Cool Dialysate or Midodrine," Am J Kid Dis 2002; 39(1): 102-107. (Transonic Reference # HD249A)

19. Pandeya S, Lindsay RM, "Cardiac Output and Access Flow during Hemodialysis [HD]: Are They Related?" J Am Soc of Nephrol Abstr 1998; 9: 179A. (Transonic Reference # HD74A)

References

20. Krivitski NM, "Cardiac Output Measurement in Extracorporeal Systems by Ultrasound Velocity Dilution," ASAIO Abstracts 1994; 82. (Transonic Reference # HD3T)

21. Depner TA, Krivitski NM, "Influence of Access Blood Flow (AF) on Systemic Blood Flow in Hemodialysis Patients," J Am Soc of Nephrol Abstr 1997; 8: 155A. (Transonic Reference # HD23A)

22. Depner T et al, "Peripheral Resistance and Systemic Blood Flow in Hemodialysis Patients," J Am Soc of Nephrol Abstr 1998; 9: 170A. (Transonic Reference # HD58A)

23. Krivitski NM et al, "Measurement of Cardiac Output and Central Blood Volume during Hemodialysis: Sources of Error," 25th International Congress of Nephrology Abstract 1999; 333. (Transonic Reference HD95A)

24. Basile C, Lomonte C, Vernaglione L et al, "The relationship between flow of arteriovenous fistula and cardiac output in haemodialysis patients," Nephrol Dial Transplant 2008; 23: 282–287 (Transonic Reference HD7542A)

25. Schier T et al, "Incidence of Arteriovenous Fistula Closure Due to High-output Cardiac Failure in Kidney-transplanted Patients," Clin Transplant. 2013; 27(6): 858-65 (Transonic Reference # HD9869AHR)

26. Stern AB, Klemmer PJ, "High-output Heart Failure Secondary to Arteriovenous Fistula," Hemodial Int. 2011 Jan 12.

27. Wasse H, Singapuri MS, "High-output heart failure: how to define it, when to treat it, and how to treat it,"Semin Nephrol. 2012; 32(6): 551-7.

28. Hooper DK et al, "The quality of cardiovascular disease care for adolescents with kidney disease: a Midwest Pediatric Nephrology Consortium study," Pediatr Nephrol. 2013 Jun;28(6):939-49. Nefrologia. 2015 May-Jun;35(3):234-45. (Transonic Reference HD10619AHR)

29. Alkhouli M et al, "Cardiac complications of arteriovenous fistulas in patients with end-stage renal disease," Nefrologia 2015; 35(3): 234-45. (Transonic Reference HD10618AHR)

30. Huu, TC et al, "Access Flow (Qac) and Cardiac Output (CO) Measurements by Non-Invasive Methods in Hemodialysed Patients." Angioaccess for Hemodialysis, 2nd International Multi-disciplinary Symposium. May 31-June 2, 1999, 170. (Transonic Reference # HD108A)

31. Huu TC et al, "Detection of High Access Flow (Qac) and Cardiac Output (CO) in Hemodialysed Patients," J Am Soc of Nephrol Abstr 1999; 10: 202A. (Transonic Reference # HD129A)

32. Huu, TC et al, "Non-Invasive Measurement of Access Flow (Qac) and Cardiac Output (CO) in Hemodialysis Patients," Nephrol Hemodialy Transplant 1999; 14(9): A175. (Transonic Reference # HD34V)

33. Barril, G et al, "Vascular Access (VA) Assessment by Dilutional Methodology (Transonic QC)," J Am Soc Nephrol, 1999; 10: 201A. (Transonic Reference # HD42V)

34. Schneditz D et al, "Systematic Underestimation of Cardiac Output by Thoracic Bioimpedance in Hemodialysis Patients: Relation to Access Blood Flow," J Am Soc of Nephrol Abstr 1999; 10: 217A. (Transonic Reference # HD131A)

35. Depner TA et al,"Contraction of Central Blood Volume and Reduced Cardiac Index in Hemodialyzed Diabetic Patients," J Am Soc of Nephrol Abstr 2000; 11(3): 263A. (Transonic Reference # HD154A)

36. Dobson A et al, "Cardiac End Diastolic Blood Volume from Cardiac Output during Hemodialysis," J Am Soc of Nephrol Abstr 2000; 11(3): 264. (Transonic Reference # HD155A)

37. Kiaii M et al, "What "Blood Volume" Do We Dialyze?" J Am Soc of Nephrol Abstr 2000; 11(3): 277. (Transonic Reference # HD156A)

38. Lindsay RM et al, "Extracellular Fluid (ECF) and Blood Volume Changes during Hemodialysis [HD]," J Am Soc of Nephrol Abstr 2001. (Transonic Reference # HD213A)

39. http://www.fistulafirst.org/Professionals/FrequentlyAskedQuestions.aspx#Q5

40. Cheung AK et al, "Cardiac diseases in maintenance hemodialysis patients: results of the HEMO Study," Kidney Int. 2004; 65(6): 2380-9. (Transonic Reference # HD10620AHR)

41. Korsheed S et al, "Effects of arteriovenous fistula formation on arterial stiffness and cardiovascular performance and function. Nephrol Dial Transplant 2011; 26(10): 3296-302. (Transonic Reference # HD10622AHR)

42. Raza F, et al, "Case series of 5 patients with end-stage renal disease with reversible dyspnea, heart failure, and pulmonary hypertension related to arteriovenous dialysis access,"Pulm Circ 2015; 5(2): 398-406.

43. Basile C, Lomonte C, Konner K. "The arteriovenous fistula: lesser evil or God's blessing?" Blood Purif 2011; 32: 253.

44. Wasse H1, Speckman RA, McClellan WM, "Arteriovenous fistula use is associated with lower cardiovascular mortality compared with catheter use among ESRD patients," Semin Dial 2008; 21(5): 483-9. (Transonic Reference # HD10636AHR)

HOW HEMODIALYSIS PATIENTS Can Take Charge of Their Care

A GUIDE FOR PATIENTS AND CARE PARTNERS

Having a diagnosis of end stage renal disease or chronic kidney disease can leave you experiencing many emotions. You may feel a sense of despair knowing that your condition is chronic or worsening. You may feel isolated and that no one understands what you're going through. You may also feel overwhelmed at your prognosis and treatment options.

Simple things like knowing your dialysis options, how to care for your access and receiving or providing support can improve your physical and mental health, which can help limit complications.

This guide will provide you with the tools to help you take charge of your care.

Get Familiar with Your Access

In order to receive dialysis, you're going to need an access. Your access allows the blood from your body to be cleaned and filtered.

Your access has three primary forms: **a fistula, graft or catheter.**

FISTULA

A fistula surgically connects your vein to an artery. This results in increased blood flow to that vein, which allows the vein walls to strengthen. Needles are then inserted in the fistula for hemodialysis. Fistulas are the preferred access because of their low complication rates.

GRAFT

A graft is a synthetic tube that's connected to your blood vessels. Like the fistula, needles are inserted into it for hemodialysis, but unlike the fistula the risk for complications is higher because it is made of synthetic materials.

CATHETER

A catheter, or a central venous catheter, is a tube-like device that's inserted into a vein in your neck or groin. A portion of the tube remains outside your body, while the other travels under your skin into a vein. The tubes are then connected to the dialysis machine when you receive treatment. Because parts of the tube remain outside the body, the risk for infection and other complications is high. This type of access is primarily used as a temporary access until you can receive a graft or fistula.

The phrase "your lifeline for a lifetime" might be familiar to you. That's because a vascular access allows your blood to flow into and out of the dialysis machine. But only a few sites on your body can be used for an access. So, once you have an access established — whether it's a fistula or graft, it's essential to care for it properly.

The One-Minute Check

It only takes a minute to keep your access working as it should and avoid infection. Early detection of issues allows you to get prompt treatment, which will extend the life of your access. **Here's how to do a "one-minute check" of your access**.

It Only Takes a Minute To Save Your Lifeline

Look

The skin over your access is all one color and looks like the skin around it.

GO

There is redness, swelling or drainage. There are skin bulges with shiny, bleeding, or peeling skin.

STOP

Listen

When you place your access next to your ear, you hear a sound. And it sounds the same as the last time you checked it.

GO

You place your access next to your ear and hear no sound. Or it sounds different than it did last time you checked it.

STOP

Feel

Thrill: a vibration or buzz in the full length of the access. **Pulse:** slight beating like a heart-beat. Fingers placed lightly on the access should move slightly.

GO

Pulsatile: The beat is stronger than a normal pulse. Fingers placed lightly on the access will rise and fall with each beat.

STOP

If you notice any of the red signs, contact your dialysis care team immediately at the numbers provided.

Contact: _____

During business hours: _____

After business hours: _____

In addition to performing the one-minute check, you will want to make sure you:

- Don't use your access arm for heavy lifting or carrying purses
- ☐ Ensure your access arm isn't constricted by heavy clothing, which can act as a tourniquet to your vascular access

Know Your Dialysis Options

Dialysis helps filter your blood and do the work your kidneys no longer can. There are four options for hemodialysis:

IN-CENTER HEMODIALYSIS

These sessions typically happen three times per week in a dialysis facility.

HOME HEMODIALYSIS

These sessions happen in your home and you serve as a dialysis technician, inserting needles and operating the machine.

NOCTURNAL HEMODIALYSIS

As the name suggests, these sessions are done at night while you sleep. They can take place at home or in a center.

SHORT DAILY HOME HEMODIALYSIS

These sessions are about half the length of a regular hemodialysis session and occur five to seven days a week.

Is Home Hemodialysis Right for Me?

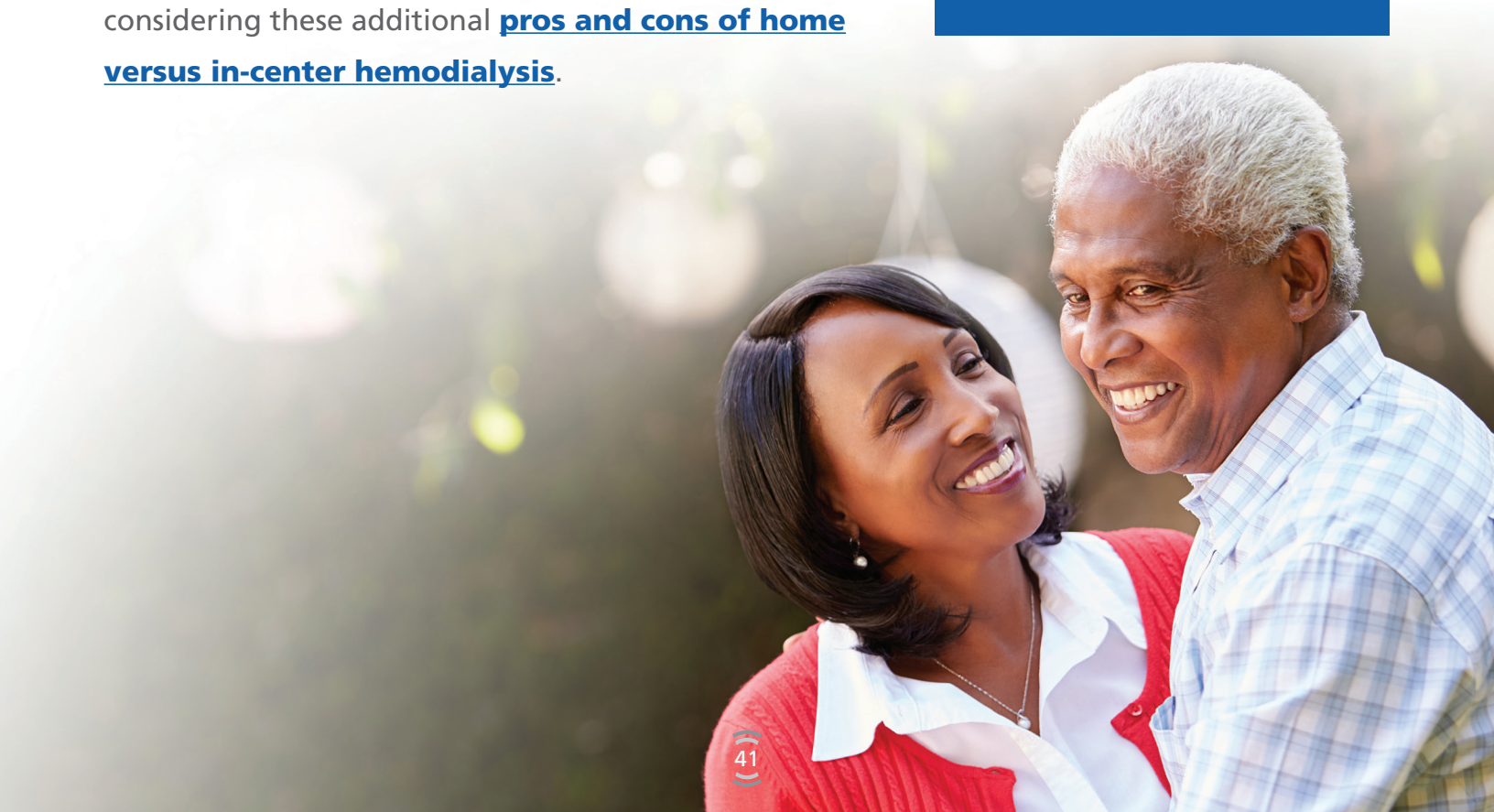
Home hemodialysis requires you to be in charge of all phases of dialysis. If you want to do home hemodialysis, you'll need to undergo training at a dialysis center and learn to insert needles. To be successful, you have to be willing to learn and do home hemodialysis for at least a year and have a center and care team willing to train you and follow your care, according to **the National Kidney Foundation**.

If you're considering home hemodialysis, **but aren't sure if it's the right choice for you**, Homedialysis.org recommends thinking about the things you like or want to do—like travel or work—and consider what you don't want—like spending hours at a center or keeping a machine and dialysis supplies in your home.

Additionally, the National Institutes of Health suggests considering these additional **pros and cons of home versus in-center hemodialysis**.

Wondering which treatment option is right for you? This tool from the Medical Education Institute (MEI) can help you find one that meets your needs.

Use the Tool



Consider Learning Self-Cannulation

Whether you've chosen in-center or home hemodialysis, learning how to self-cannulate can increase your confidence and establish a greater sense of control. However, many patients feel uneasy about the process.

Self-Cannulation: Easing Fears

Your self-cannulation fears are not unique. Sixty-three percent of patients who had not yet undergone dialysis reported they could self-cannulate on their own or with help, but after receiving their first treatment in the hospital, 53 percent of patients said they didn't think they could do the procedure. Why? In addition to a fear of needles, patients cited fear of infection, excessive bleeding, pain and watching the needle be inserted.

Even if you have previously received hemodialysis in center or are struggling with the idea of self-cannulation, there are steps you can take to reduce fears and self-cannulate successfully.

These include:

- Watching someone else get their needles inserted
- Watching — even if it's just a glance at first — your own needles be inserted
- Holding your sites at the end of treatment
- Asking the staff if you can hold a needle in your hand to get used to how it feels
- Using a cream or gel to numb your access if you're concerned about pain
- Asking the staff to teach you how to insert the needles

Also, try the advice below to ease your fears.

Establishing control

Control can take three forms: mental, physical and lifestyle, according to study authors. Mental control, according to patients from the study, involves not allowing a fear of needles or cannulation to grow in your mind.

“When a needle goes in, it’s not the needle you’re scared of, it’s the thought of the needle going in that scares you. It’s the feelings we sort of make. It’s your mind playing tricks on you,” said one patient.

Patients also want the physical control of inserting the needles themselves and to have greater control over their lifestyles through home hemodialysis.

Building confidence

This involves creating and maintaining confidence through training and support from members of the dialysis care team. Many patients reported their nursing and care team provided them with the confidence they needed to begin home hemodialysis. Confidence can also come from patient education. One patient reported his confidence increased after he read literature on self-cannulation and taught himself to do the procedure.

Normalization

For many patients, the success of self-cannulation came after they accepted that the procedure was part of their identity and had become the norm for them.

Create a Support Team

Chronic kidney disease or end stage renal disease care requires a team effort. Your dialysis care team typically consists of several people who will oversee your care including:

- A nephrologist
- An advanced practice practitioner like a physician assistant or nurse practitioner
- A nephrology nurse
- A renal dietitian and social worker
- A patient care technician
- A vascular access coordinator

Your team will oversee your care while you are receiving dialysis treatments in center, but it's equally important to have a friend or family member be aware of your health and current treatments. They can advocate for you if you are unable to do so.

Questions to Ask Before You Start In-Center Hemodialysis

Consider asking your care team these questions before beginning treatment at a center:

- How do I choose a dialysis center or facility? _____
- What is the process for first treatments? _____
- How many stations are there and how many shifts? _____
- Can I eat or drink while being treated? _____
- What precautions are taken to ensure infection control? _____
- How often will I see the nephrologist? _____
- Do you offer support groups for patients or families? _____
- Who will be cannulating? _____
- Do you encourage and teach self-cannulation? _____
- Are patients taught how the dialysis machines work? _____
- Am I able to modify my schedule, if needed? _____
- Do you offer home hemodialysis? _____
- How will my vascular access be checked for proper function? _____

Questions to Ask Your Support Team about Home Hemodialysis

Though you'll receive extensive training on home hemodialysis from your in-center care team, there are some things you still might be wondering about. Consider asking your care team these questions about home hemodialysis:

- Is the cannulation process different at home than in-center? Will I need to adjust the position of my arm or reach angle to cannulate my access? Will how I hold the needle, tape the needle and remove the needle be different?
- What equipment do I need to start home hemodialysis?
- Do I need a dedicated room for dialysis? What electronic, plumbing, internet and phone connections do I need?
- What storage space will I need?
- How clean will I have to keep my dialysis area to ensure my success?
- How often do I need to return to the center for additional training or a refresher once I go home?
- Is respite care available if my care partner or I need a break?
- Is a nurse available to help me set up at home for my first treatment?
- Would I need to come back to the center for any medications? Can I be taught to give my medications at home? What about my anemia management and bone disease management?
- Who do I call if I have questions?
- How can I make sure my dialysis prescription is right?

Join a Support Group

Living with chronic kidney disease not only takes a physical toll, it can take an emotional one as well. It can be difficult, whether you've been living with the disease for a while or are a newly diagnosed patient, to process your emotions. Not only that, but attempting to express your concerns during a short office visit with your care team can leave you feeling frustrated as well.

Social support from peers with chronic kidney disease can help. **Studies have shown** that social support, like that received in support groups, improves survival rates and quality of life for those on dialysis. Why is peer support so effective? It gives you something you can't receive at a clinician's office — shared life experiences.

"Research shows that people often cope better when they interact with peers with whom they identify and share common experiences," according to **the National Kidney Foundation** (NKF). "In this way, feelings are validated, social isolation and stigma are reduced, hope for the future and optimism grows, and experiences are normalized,"

It has also been shown that the mentee — or person providing the help—receives improved health benefits from providing social support.

Find the Support that's Right for You

Attend a support group, gather more information, speak to someone on the phone or form your own support group using the information below.

The NKF helpline: 1.855.653.2273

Become a mentor or find out more about support services in your area on the **NKF Peer site**.

Find information about support groups in your area, by visiting the **American Association of Kidney Patients' listing**.

If you're interested in forming your own support group, the **Renal Network has a helpful guide**.

Get support for home hemodialysis by visiting **Home Dialyzors United** and **Home Dialysis Central**

Learn about the myths and realities of home hemodialysis with this **booklet** from the ESRD NCC.

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