

Module 16

Long-term Effects of Dialysis



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Please Note

Use of Kidney School does not replace the need to talk with your health care team about your care and your options.

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		d	(5)
	c		(4)
	d	a	(3)
	d	b	(2)
	a	c	(1)

Congratulations, you've finished the quiz! Here are the correct answers so you can see how you did:

Module 16 – Kidney Quiz Answers





The great humorist Mark Twain once said, “Never put off until tomorrow what can be put off until the day *after* tomorrow.”

This is classic Twain looking at life a little off-center. But the reason we find it funny is that it has some truth in it. When we face something tough or unpleasant, we often prefer to avoid it for as long as we can. Sometimes we ignore it until it *forces* us to notice it.

Some hard things in life can be put off or ignored. But kidney failure isn't one of them. It will demand your attention, even if you try to pretend it doesn't exist.

This module is about long-term health problems that can occur with dialysis. By taking good care of yourself, you can delay or prevent some problems that might otherwise arise down the road. You can have more time, feel better, and be able to do things you care about. We want you to be able to take steps to protect yourself, and live long and well with kidney failure.

Whether you're new to dialysis and looking down the road, or you've been on it for years and are now running into some of these issues, this module is for you. At the end, we'll give you a Personal Plan that lists the main points we've made and reflects *your* action points.

So, let's get started.

Choosing the Life You Want

Your best bet to feel your best and avoid long-term effects of dialysis is to make good choices and take care of yourself. To do this, you need to truly believe that your life is worth living—and that you have something to live for.

So, what matters most to *you*?

Sometimes in the course of getting through one busy day after the next, we can lose track of our dreams: what we want out of life. What we want to do for others. What we want to achieve or be or do.

Here's your chance to take a few moments and think about your dreams. What inspires you in life? What gives you the most joy? What are you looking forward to? Check as many as apply:

- Caring for my children and/or grandchildren
- Helping a loved one who needs me
- Seeing my _____ get married
- Seeing a loved one graduate from high school or college
- Getting a college or graduate degree myself
- Finishing high school or getting a GED
- Taking a trip to:





- ❑ Helping people with:

- ❑ Getting a promotion at work
- ❑ Having a special birthday or event
- ❑ Getting married
- ❑ Becoming good at a sport or hobby
- ❑ Winning the lottery
- ❑ Having a holiday celebration
- ❑ Becoming famous
- ❑ Going to a family reunion
- ❑ There is nothing for me to look forward to

Are you putting limits on yourself because of your dialysis and stopping yourself from doing things you *could* do? It's easy to take on a "sick role". But with a chronic disease that won't go away, focusing only on your illness can leave you feeling empty. Your life needs to be about more than just dialysis. What can you plan and look forward to?

If you can't think of even one to look forward to, you might be depressed. Signs of depression can include:

- Not enjoying things you used to like
- Loss of appetite (or eating too much)
- Trouble sleeping (or sleeping too much)
- Feeling irritable or angry
- Feeling sad and down
- Loss of hope
- Feeling worthless or thinking that everything goes wrong for you
- Having no energy, being exhausted

It can be hard to sort out depression from kidney disease or other health problems you may have. But depression can be treated. Getting help can improve your outlook on life—and inspire you to take good care of yourself. Every dialysis clinic has a social worker with a master's degree and training to help people who are depressed. You can learn more in Module 5—*Coping with Kidney Disease*.

Another option to improve a poor quality of life may be to change the *type* of dialysis you do. Treatments that work more like healthy kidneys can reduce symptoms and help you sleep better. You may think more clearly and have more energy. To learn more about types of dialysis, read Module 2—*Treatment Options for Kidney Failure*.

A poor quality of life may make you think your best days are behind you. When you have severe pain or other illness, a day may come when you choose to stop dialysis. If so, talk with your loved ones and your care team. You are the only one who can make this choice, but you'll feel better if those close to you know your thoughts. You may also want to talk with your minister, rabbi, priest, or imam. Most religions think of stopping treatment as letting nature take its course. It is not suicide. If you choose to stop treatment, your doctor can refer you to Hospice, which can help you and your family. You would also have a chance to gather your loved ones around you—and these can be treasured times that most people don't have.

Embracing life—and knowing *why* you do it—can guide you to make choices that will help you create the future you want.

In this module, we are going to focus on four long-term problems:





- 1 Heart disease
- 2 Bone disease
- 3 Amyloidosis
- 4 Nerve damage

Heart Disease

Heart disease is the number one cause of death for people on dialysis—just as it is for other Americans. When you protect your heart, you improve your chances of living long and living well on dialysis.

Dialysis, fluid, and your heart

Much of how you feel after each dialysis treatment depends on how much fluid is removed, and how quickly. In the long-term, how fluid is removed can affect your heart.

When your kidneys fail, fluid builds up in your body in three “spaces”:



- 1 Inside your cells
- 2 Between your cells
- 3 In your bloodstream

Dialysis can only remove fluid that is *in your bloodstream*. Only about 15% of the fluid in your body is in your bloodstream at any given time.

Trials and Tribulations of Fluid Removal

Feel like you have the flu after a dialysis treatment? You're not alone. If you have to take off a lot of fluid in a short time, you can feel pretty wretched. Here's how one patient describes it:

“I always look the worst of all of the other patients when I come off of the machine. It never fails that I always feel not only tired, but very weak. Sometimes I have a slight headache or feel dizzy. I have tried everything.

I always have to sit for a while (10 to 15 minutes). I get on the scale, and then I go out to my car, and then have to sit a little while longer so I can drive home. I always head straight for the bed. The next morning, after enough sleep, I feel fine again.

I know of some people who come off of dialysis feeling great. I don't get that. I can't hardly function then. I know of some people who go to work after dialysis, and I don't know how they do it. I feel weak climbing the stairs after treatment. What is wrong with me? My labs look great. It is just when I come off of that machine that I catch it hard. One of the things I miss about peritoneal is that I did not have the 'hangover' that hemo gives me.” —Ed



Cardiac Emergency

“I had quite an event this weekend. They think it was a problem with not taking enough fluid from me on dialysis and my dry weight should be lower than they have it. Anyway, early Friday morning I had trouble breathing. I was gasping for air and afraid I was dying. I called 911 and the emergency team came within five minutes. They gave me oxygen and put in an IV. I was near passing out but they made me stay awake. In the emergency room they kept up the oxygen and gave me some morphine to ease my panic. They took X-rays, etc.

I had too much fluid in my lungs and it looked for a while like I had congestive heart failure. My blood pressure was up to 200 over 125. They were ready to put a tube into my lungs but my breathing got a little better so they didn't. Thank goodness! Then they rushed me up to dialysis in the hospital. I felt much better after that as fluid from around my lungs was taken out. Then they thought I might have had some heart damage, so they ran me through the CT scan, sound scan, simulated treadmill, blood work, etc. and said there may be damage to a small part on the bottom of the heart, but they would treat it with medicine. I never had any chest pains, so they figure it was not a crisis at the moment. I am feeling pretty good now and came home Monday. I hope to never have to go through that again!” —Jerry

Dialysis takes fluid out of your blood. At the same time, some of the fluid in and between your cells slowly moves into your blood to replace it. Dialysis can take fluid out of your blood faster than it can move in. Even after a treatment, you may still have extra fluid in and between your cells.

Taking off a lot of fluid in a short time can make your blood pressure drop. This can harm your access and give you painful cramps and a headache. You may even feel sick to your stomach or throw up. It may take six hours or more to feel well after a standard in-center hemodialysis (HD) treatment when a lot of fluid is taken off quickly. On peritoneal dialysis (PD), taking off a lot of fluid can make you feel sick and washed out.

Over time, extra fluid can build up in your body—and it can damage your heart.

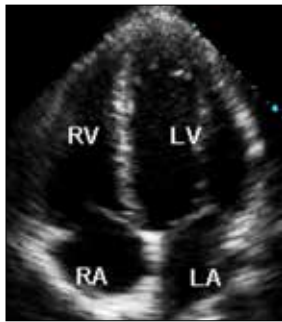
Left ventricular hypertrophy (LVH)

Each day, your heart beats about 115,000 times. It's your heart's job to pump blood through your body so each cell gets the oxygen and nutrients it needs.

Your heart has four pumping chambers; the largest is the left ventricle. If your body holds too much fluid, your heart has to work much harder. And if you have high blood pressure, your blood vessels become stiff, which makes more work for your heart, too. These problems can force your heart to work so hard that the left ventricle becomes thick and enlarged. This is called *left ventricular hypertrophy*, or LVH.

With LVH, overgrown, flabby heart muscle takes up space that should be used for pumping blood. When the heart can't pump out all the blood that comes in, blood backs up into the lungs. In time,





Healthy Heart



Heart with LVH

the heart can fail slowly—or quickly. LVH is the leading cause of sudden death in people on dialysis.

The best way to avoid LVH is by keeping fluid levels in your body as close to normal as possible all the time. Also, if you have diabetes in control, keeping your blood sugar steady will help keep you from drinking too much because you're thirsty.

If you have high blood pressure or water weight gain, eating less salt can help. Salty foods make you retain fluid. Having salt in your system also makes you thirsty so you drink more. This means a high-salt diet is a double whammy for your fluid intake. To learn more about eating less salt, read Module 9—*Nutrition and Fluids for People on Dialysis*.

PD and LVH

If you need to use 4.25% dextrose bags often, or you retain the solution and don't get good drains, talk with your PD nurse. If your doctor prescribes blood pressure pills, take them as directed.

Standard in-center HD and LVH

On standard in-center HD, the most important thing you can do to prevent LVH is to follow your fluid limits and take your blood pressure and "water-pills" as your doctor prescribes.

Medicine Can Cause Dry Mouth and Thirst

Some drugs can cause dry mouth or thirst, so ask your doctor or pharmacist about your drugs. Your doctor may be able to switch you to a drug that doesn't cause this problem.

Healthy kidneys work 24 hours a day, 7 days a week (168 hours a week). With 9 to 12 hours of treatment per week, *you* need to do part of the work of cleaning your blood by drinking less fluid. If you choose to do more dialysis (like daily or nocturnal home HD), your treatment will remove more fluid, so you can have a more normal fluid intake.

Your center may do *sodium modeling* (add some sodium into your blood) to make your treatments feel better. If so, you may be left with extra salt that can make you thirsty. This can make it much harder to follow your fluid limits—which can cause a vicious cycle. Eating less salt and drinking less fluid may allow the staff to use less sodium in your modeling program.

Daily or nocturnal HD and LVH

Daily or nocturnal HD help you protect your heart by taking off a lot of fluid, but slowly and gently. Most people who do home HD treatments can take fewer blood pressure pills—maybe none at all.

Statins and heart failure

Like millions of American adults, you may have high cholesterol. Many people are prescribed a statin drug for high cholesterol. Statins lower



cholesterol by blocking a certain pathway in your body. Some common statins include:

- Lipitor® (atorvastatin)
- Pravachol® (pravastatin)
- Crestor® (rosuvastatin)
- Zocor® (simvastatin)
- Lescol® (fluvastatin)
- Vytorin® (simvastatin + ezetimibe)

Testing your heart

The good news is that LVH can get better. If you don't have it, you can help prevent it. And if you *do* have it, you can take steps to improve your heart health. Ask your doctor about testing for LVH—you can have it with no symptoms (or you may be short of breath, dizzy, or have chest pain).

Research has found a number of tests that can check for the problem. Check off the ones you want to ask your doctor about:

- **Echocardiogram.** An “echo” uses painless sound waves to show your pumping chambers and valves. It will show the size of your left ventricle and how well it works. The results can predict future problems.
- **24-hour blood pressure (BP).** With

a small machine on your belt and a cuff on your arm, your BP can be checked all day and night. This tells your doctor much more than a single check. If your BP is high all the time or does not drop at night (it should), you need to take steps to lower it.

- **Bioimpedance analysis (BIA).** BIA can check for fluid overload by looking for fluid in and outside of your cells. This technique uses sensors on your head and neck (one type is called Bio-Z). It is painless and non-invasive. BIA predicts LVH in people on dialysis.
- **C-reactive protein (CRP).** A CRP blood test measures inflammation, which has been linked to heart damage in people on dialysis.

If tests show that you have LVH, some things you can do include:

Quit smoking. Besides causing lung and kidney damage, tobacco use has been found to raise the risk of LVH by 42%. If you smoke, stopping can help protect your heart. Can't do it alone? Ask your doctor about prescription drugs to help you, or join a stop-smoking program.

Eat enough protein. Low serum albumin (protein) levels seem to make LVH get worse faster. If you can't eat enough protein, you may not be getting enough dialysis to keep up your appetite. Getting more treatment can help your heart.

Do You Need CoQ10?

If you take a statin, ask your doctor if you should take the supplement Coenzyme Q10 (CoQ10), too. Statins use up CoQ10, which is a key enzyme the body needs for energy. Not having enough CoQ10 can cause congestive heart failure.





Ask about ARBs and ACE inhibitors. Some blood pressure drugs in these two classes have helped to reverse LVH.

Get bone disease treated. Having renal bone disease makes LVH worse. Taking active vitamin D (calcitriol) has been shown to improve it, so, if your doctor says it's safe, you can do your bones *and* your heart a favor at the same time. We'll talk more about bone disease on page 16-11.

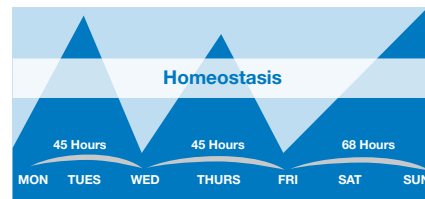
If you are on standard in-center HD, get more dialysis. Daily and nocturnal HD remove much more fluid from in and between your cells. These treatments can help prevent (or treat) LVH. In a year-long study, both options shrunk left ventricles much more than standard in-center HD.

Nocturnal HD improves LVH in patients with known heart problems. The treatment helps make arteries less stiff so they respond as they should to stress. People who switched from standard to nocturnal HD had less LVH—and lower blood pressure.

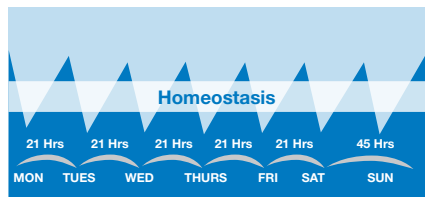
Your dialysis *schedule* can also affect your risk of sudden death from LVH. Two large studies found *twice* the risk of sudden death on Monday or Tuesday (after the weekend) than on any other day of the week. The ups and downs of treatments three days per week (see graphs above right) are hard on the heart. Doing treatments at least every other day is more gentle.

Dialysis: removing toxins

As we said before, how you feel after a dialysis treatment is all about removing fluid. In the *long* term, how you feel depends on other illnesses you may also have—and on how well toxins are removed.



No normal levels of water or wastes with standard in-center HD



Normal levels of water and wastes with PD, daily, or nocturnal HD

Think of a dialyzer as a filter you might use to pan for gold. The holes need to be big enough to let toxins (small gravel and rocks) out—but not so big that they let blood cells or protein (gold!) escape.

In your blood, there are three main sizes of toxins to remove, so they don't build up to harmful levels:

- 1 **Small molecules** (like urea) easily fit through dialyzer holes. They are very easy to remove. Scientists have found 68 small molecule toxins.
- 2 **Middle molecules** (like beta-2-microglobulin—more about this later), are larger and harder to remove. There are ten middle-molecule toxins.
- 3 **Large molecules** (like cytokines, hormone-like signal proteins) are even harder to remove. Twelve large-molecule toxins have been found.

The more middle and large molecules your treatments can remove along with the small ones, the more likely you'll feel well for a long time. Middle and large molecules take *time* to remove.



They pass through the dialyzer very slowly. “Adequacy” of dialysis tests are based on small molecules, but it is middle and large ones that can cause problems for you down the road.

Removing toxins with PD

Since you do PD all day long or for a long time each night, it can do a very good job of removing middle and large molecules.

Over time, your peritoneum may remove fewer toxins and less fluid. One sign that this may be going on is if you start to retain the PD fluid. A *peritoneal equilibrium test* (PET) can also tell. You can help protect your membrane if you:

- Use careful technique and avoid infection.
- Watch your fluid intake so you can use as few 4.25% bags as you can (the sugar content in 4.25% bags can damage the peritoneal lining).
- Use icodextrin PD fluid for the night dwell instead of a fluid based on sugar.

Removing toxins with standard in-center HD

Standard in-center HD does a good job of taking out small molecules. It does not do as well with middle and large molecules.

An option for better toxin removal with standard HD may be to use two dialyzers at each treatment. In a small study of people who weighed more than 176 lbs. (80 kilos), health status was better for a year when two dialyzers were used. Reuse of the dialyzers would bring down the cost. It can be tricky to do with machines that were built for one dialyzer, though.

Removing toxins with daily HD

Daily HD does a good job of taking out small molecules—and a good job with middle and large molecules.

Removing toxins with nocturnal HD

Nocturnal HD does the best job of taking out molecules of all sizes. If you are doing three nights per week of dialysis, a way to remove even *more* toxins (and fluid) is to add a night or two. This can't always be done—Medicare pays for three treatments per week. Your doctor may be able to write a letter to Medicare to see if a fourth (or more) treatment would be paid for. If you have a health plan through a job, it may pay for the other treatments. People who do nocturnal treatments five or six nights per week say they feel even better.

Most people still have *some* kidney function when they start dialysis. Keeping this function as long as you can helps dialysis work better. Below are some ways that you can help keep your kidney function. Which ones can *you* do? Check all that apply:

- Quit smoking if I smoke.** Smoking causes damage to the kidney filters.
- Keep my blood pressure in the target range** my doctor gives me.
- Keep my blood sugar in the target range** if I have diabetes.

Longer HD Treatments=Longer Life

A study of more than 22,000 people on dialysis all over the world found that longer HD treatments were linked with longer life. In fact, each extra 30 minutes of treatment improved the chance of survival by 7%. With dialysis, more is better!



- ❑ **Protect your kidneys from X-ray contrast dye.** The radiologist can dilute the dye, flush it out of your body with saline, use a less harmful dye, or prescribe a drug called *mucomyst* that may help prevent damage.
- ❑ **Avoid non-steroidal pain pills** (called NSAIDs), like ibuprofen and naproxen. Some common brands are Advil[®], Aleve[®], and Motrin[®], but there are many others. Not sure if a pill you take is an NSAID? Ask your pharmacist or doctor.
- ❑ **Ask your kidney doctor before you take any herbs.** Some can damage the kidneys.
- ❑ **Ask about a new drug *before* you take it.** Some drugs can harm the kidneys, and any drug that you are allergic to may cause kidney damage. Know what you're taking—your pharmacist can tell you if a drug can hurt your kidneys. If another doctor prescribes a drug for you, ask your nephrologist before you take it.

Renal Osteodystrophy (Bone Disease)

Renal osteodystrophy is bone disease due to kidney failure. The problem is quite common—most people on dialysis have some degree of it. Bone changes can start many years before symptoms appear, like:

- Joint pain
- Bone pain
- Fractures

To understand renal osteodystrophy, you need to know a little about your bones. Bones have three key jobs in your body:



- 1 Hold up your body and protect your organs
- 2 Store minerals your body needs
- 3 Make red blood cells

Bones seem solid, even rock-like. But if you look at them under a microscope, old bone is being broken down, and new bone is being formed. This is called “remodeling”—and it’s like redoing your kitchen. If you tear down walls without leaving supports, the ceiling may fall in. If old bone breaks down faster than new bone can replace it, your bones could become weak. Weak bones can break.

Healthy kidneys help ensure healthy bones by keeping the bone building minerals (calcium and phosphorus) in balance in your blood.



Calcium

Calcium is the most common mineral in your body. It's needed in your blood in very precise amounts to:

- Send nerve signals
- Help your muscles work
- Aid in clotting your blood when you're hurt
- Control fluid balance in your cells

You get the calcium your body needs by eating foods that contain it. Dairy is a good source of calcium. Most calcium in your body is stored in your bones—like a bank. Remodeling your bones is a way for your body to take calcium out of your bank.

The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (NKF KDOQI™)

Guidelines for people on dialysis say that your blood calcium level should be at the lower end of the normal range for your center's lab. In most cases, this means from about 8.8 to 9.5 mg/dL, and not higher than 10.2 mg/dL.

Phosphorus

Phosphorus is a common mineral that your body needs for energy. It's found in nearly all foods, especially:

- Meats
- Dairy products
- Whole grains
- Chocolate
- Cola drinks
- Dried beans

Like calcium, phosphorus is stored in your bones. Remodeling lets small amounts of it into your

Turning to Stone: Calcified Blood Vessels

You know that too much phosphorus causes itching and bone problems.

Having the wrong levels of calcium and phosphorus in your blood can also harm your blood vessels. Calcium phosphate crystals can form in arteries and veins, making them calcify (turning them—quite literally—to stone).

Stone-like blood vessels can't respond to changes in your activity level. Stone-like heart valves can't pump your blood, which can lead to heart failure. Research has found that phosphate binders based on calcium, like Os-Cal® or PhosLo®, can cause this problem or make it worse if calcium levels are too high. Non-calcium binders, like Renagel®,



Fosrenol®, or Renvela®, are less likely to make blood vessels calcify, but they cost more.

When you get more dialysis (e.g., daily or nocturnal HD), or have a transplant, you don't need as many binders. This is something to think about to help you live long and well with kidney failure.

Your doctor can see how much of a problem you have with blood vessel calcification by doing an X-ray, ultrasound, CT scan, or electron beam tomography (EBT). An echocardiogram (echo) test to see how well your heart pumps can also help.

Do you have calcified blood vessels now? Getting more dialysis may help shrink the deposits. Also, osteoporosis drugs called *bisphosphonates* show some promise for treating this problem.





blood. Healthy kidneys remove extra phosphorus from your blood. When the kidneys fail, extra phosphorus can bind with calcium to create sharp, calcium phosphate crystals. These crystals can cause itching, skin sores, and worse. In the long term, having the wrong levels of phosphorus in your blood can harm your bones.

Phosphorus is hard to remove with dialysis—and each time you eat, you take in more. The NKF KDOQI Guidelines for people on dialysis say that

your phosphorus level should be between 3.5 and 5.5 mg/dL. To stay in this range, most people on dialysis need to eat fewer high-phosphorus foods and take some *phosphate binders* with each meal and snack. These drugs bind with phosphorus and remove it in your stool.

Getting more dialysis by doing daily or nocturnal treatments will remove more phosphorus so you need fewer binders and can eat a more normal diet. In fact, people who do nocturnal HD 5 or

When Crystals Attack! Extraskeletal Calcification & Calciphylaxis

A high calcium-phosphorus product (see page 16-14) means extra calcium and phosphorus are in your blood, where they can form crystals. You may find that you have bone where it doesn't belong. *Extraskeletal calcification* means bone is forming outside your skeleton. This can happen in your eyes, blood vessels, heart, lungs, or other organs. It may show up as knobs or lumps on top of bones, in joints or on tendons. In some cases, a surgeon can remove these bone lumps to help improve function.

Worse, the crystals can harm blood vessels and even cut off blood flow to a finger or toe, a whole limb, or soft tissue. This problem—*calciphylaxis*—is painful and can be fatal. It may occur in about 4% of people on standard HD. It starts as red or purple skin marks (often on both arms or legs in the same spots). They may look like bruises. A skin biopsy shows calcium in the tissues. The marks turn black as the skin dies, and turns into ulcers that grow larger and won't heal. People with diabetes are at a higher risk. Treatment for calciphylaxis may include:

- **Phosphate binders** – These help pull extra phosphorus out of the blood.
- **Antibiotics** – It is vital to prevent infection in the skin ulcers.
- **Sodium thiosulfate** – New studies have found that this drug, which pulls calcium out of the body, may be able to help. The drug is most often given in a vein, but may be given into the peritoneum.
- **Kidney transplant** – A new kidney will remove more excess calcium and phosphorus from the blood.
- **Parathyroidectomy** – Removing most of the parathyroid glands will change the balance of calcium and phosphorus in the body.
- **Hyperbaric oxygen chambers** – Used for deep sea divers with “the bends,” these chambers force oxygen into the tissues and can help heal skin ulcers. Not all hospitals have a hyperbaric oxygen chamber. To find one, put “hyperbaric oxygen chamber” *and* the name of your city and state into Google.
- **Amputation** – If a problem in a limb is not healing, removing the limb may save your life.



6 nights per week often need phosphate *supplements* instead of binders, because their treatments work so well.

Using binders and eating fewer high-phosphorus foods can help to keep your bones healthy. To learn more about eating less phosphorus, read Module 9—*Nutrition and Fluids for People on Dialysis*.

Calcium-phosphorus product

Your “product” is your blood calcium level times your blood phosphorus level. This result should be part of your monthly blood test results. The NKF KDOQI Guidelines for people on dialysis say that your product should be less than 55. You can reach this with a lower calcium level, lower phosphorus, or both. The best thing you can do is keep phosphorus in the normal range.

Active vitamin D

Healthy kidneys make a hormone called *calcitriol*, the active form of vitamin D. Calcitriol helps your gut absorb calcium from the food you eat.

What’s Calcitriol, Anyway?

Your body gets vitamin D in two ways: from foods you eat—like dairy products and fortified bread—and from sunshine on your skin. Your liver and kidneys convert vitamin D into an active form, the hormone *calcitriol*. A hormone is a signal made in one part of the body that acts on another part. Calcitriol tells your gut to absorb calcium from your food.



When your kidneys fail, they make less calcitriol. This means you can’t absorb as much calcium, even if you eat more foods that have it. If your calcitriol blood levels drop, your body will pull calcium out of your bones.

Parathyroid hormone (PTH)

Think of PTH as the withdrawal slip for your bone bank. Each time your blood calcium levels drop, your parathyroid glands kick in. These four small, bean-shaped glands in your neck, behind your thyroid, make PTH. The job of PTH is to jump-start remodeling to take calcium out of your bones.

With failed kidneys, your blood calcium levels may drop so often that your parathyroid glands make PTH over and over. In time, the glands can grow (called *hypertrophy*). They can even get so big that they *can’t* shut off.

If your PTH levels are too high, too much calcium will be taken out of your bones. This is called *secondary hyperparathyroidism* (sHPTH), and it can make your bones weak and more likely to break. The type of bone disease caused by sHPTH is called *renal osteodystrophy*. Target blood levels of PTH for people on dialysis are from 150 to 300 pg/mL.

Treatment for renal osteodystrophy

Bone disease can be prevented or treated with:

- Phosphate binders
- Active vitamin D—taken by mouth or by a vein
- A drug called Sensipar® (cinacalcet hydrochloride)
- Surgery to remove most of the parathyroid glands

Binders, as you’ve learned, pull some of the extra phosphorus out of your blood.





Vitamin D drugs replace the calcitriol your kidneys no longer make. If your calcium or phosphorus levels are too high, you can't take vitamin D. Active vitamin D drugs for dialysis include Rocaltrol[®], Hectorol[®], and Zemplar[®].

Sensipar works on the parathyroid gland to lower PTH levels and improve calcium and phosphorus levels. It is a pill that you take once a day.

Removing the parathyroid glands

If your parathyroid glands grow and make too much PTH, your doctor may want you to have them taken out (*parathyroidectomy*). This is most often done with general anesthesia.

Most people have four glands in the front of the neck, but they can be hard to find. They may hide in your chest, or you may have more than four. A first parathyroid surgery tends to be safe. Having to go back in a second time has a higher risk of surgical problems. **Ask your surgeon about:**

- Having an ultrasound before surgery to find the glands.
- Testing your PTH just before and 10 minutes after taking out the glands to be sure it has dropped enough and no glands were missed.

In some cases, the surgeon may place one of the parathyroid glands that were removed into the tissue of your forearm. This way, you can still make *some* PTH. And, if that gland gets too big, it is easy to find and remove. If all of your glands are removed and you make *no* PTH, you may be able to take PTH injections instead.

After the surgery, you may be in the intensive care unit for a few days to keep a close eye on your calcium. When high levels of PTH in your blood fall



quickly, “hungry bone syndrome” can occur—your bones try to steal calcium from your blood. You'll get to eat as much dairy food as you like in the hospital to keep your blood levels up. You may get calcium through an IV. Signs of not having enough calcium in your blood include:

- Muscle aches, tremors, or painful cramps
- Muscle spasms of the face
- A tingly or “pins and needles” feeling in your lips, tongue, fingers, or toes

If you have any of these symptoms after surgery, tell the nurse or doctor right away so they can check your blood again.

To keep your bones as healthy as possible:

- Make a plan with your care team to reach your lab value goals.
- Know your lab values and track them each month.
- Follow the diet for your type of dialysis.
- Take all your drugs as your doctor prescribes them.



What It's Like to Have DRA

What does amyloidosis feel like?

"I have been on hemodialysis for about 18 years and have been having problems with dialysis-related amyloidosis (DRA) for about 8 years. It has been giving me problems with arthritis in my shoulders, hands, hips and neck and carpal tunnel syndrome in both wrists. I have had surgeries on my hands and three on my wrists. My neck has gotten so bad lately that my doctors think I need to have my spine stabilized to keep my neck from breaking. But the bones in my neck may be too brittle to support the bracing." –David

What is Carpal Tunnel Surgery Like?

People who have been through carpal tunnel surgery explain:

"I had carpal tunnel surgery done about 5 years ago with no problems. I had it done on both hands, about 2 weeks apart. I had tape and gauze wrapped around my hand for 10 to 14 days. I was told not to use the hand while it was wrapped up. I never used a brace. It all turned out fine." –Lee

"After 26 years of ESRD and 15 of pounding away on the computer, I have nerve damage and carpal tunnel. I had my right hand done in May and am very happy with the improvement. It hasn't taken away ALL pain and numbness in my hand, but has helped it greatly." –Mary

Amyloidosis

Amyloidosis is another long-term dialysis problem that can affect your bones, joints, and tendons.

In your body, protein helps form muscle, bones, hair, and nails. Not all protein is good, though. One type of protein your body makes is beta-2-microglobulin (B₂m). Healthy kidneys remove B₂m—which is a middle molecule and a toxin. In 1985, researchers found that B₂m molecules in the body link up and form long chains of hard, waxy *amyloid*.

Amyloid deposits can form all over the body. They tend to settle in joints, bones, and tendons where they harm tissue and cause pain. This is *dialysis-related amyloidosis* (DRA). After 5 years or more of standard HD, DRA is a common cause of:

- Arthritis-like pain
- Joint damage
- Bone cysts that can lead to fracture
- Carpal tunnel syndrome (wrist pain, numbness, and tingling)

DRA is also a rare cause of:

- Enlarged tongue
- Heart problems
- Cystic or soft tissue tumors
- Inflamed colon

After 20 years on standard in-center HD, 80% of people have DRA. No one knows why one in five people *don't* have it. MRIs show amyloid in the body much better than standard X-rays or even CT scans.

Preventing DRA

If you were going to start dialysis today, how could you reduce your chance of having a harmful





build-up of amyloid in your body? There are two main steps you can take:

- 1 **Choose a treatment that removes more B₂m:**
 - PD and standard in-center HD take out some B₂m, but not enough to keep blood levels normal. Better HD membranes mean more B₂m is removed today than in the past.
 - Daily and nocturnal HD remove *much* more B₂m.
 - A kidney transplant will also remove more B₂m. Getting a transplant before starting dialysis is called *preemptive transplant*.
- 2 **Use ultrapure water for dialysis.** Inflammation seems to make DRA occur faster. Ultrapure water has less endotoxin (toxic pieces of the cell walls of dead bacteria). It may cause less inflammation in your body. Ask your clinic if it uses ultrapure water for dialysis.

Treating DRA

There is no pill to treat amyloidosis. Treatment is based on trying to help ease the symptoms or fix the damage. Some things that have been tried include:

- Steroid injections to help reduce inflammation
- NSAID pills to help with pain (though these can reduce kidney function and cause stomach bleeding)
- Physical therapy to help movement
- Surgery to remove amyloid from the carpal tunnel or other joints
- Switching to a form of dialysis that takes out more B₂m
- A kidney transplant

An adsorptive column used at dialysis has been found in studies to remove large amounts of B₂m from the blood. The column attracts B₂m like a magnet. This is costly and not yet in wide use, but it may help treat DRA in the future.

With so much research going on, you'll want to keep an eye on science news. New breakthroughs will occur to prevent or treat DRA. If you have amyloidosis, you may want to join a clinical trial (see www.clinicaltrials.gov). Often, free treatment is given to people in clinical trials.

Neuropathy (Nerve Damage)

Your nerves are like phone cables; they take signals to and from your body's surface to your spinal cord (your central switchboard).

When someone strokes your hand, that signal is carried by a nerve to your spinal cord. If someone pokes your hand with a tack, you feel this in a different way—and your nerves let you tell which is which.





Neuropathy is nerve damage. In dialysis patients, it most often affects *peripheral* nerves—in the hands and feet. Nerves can be harmed by:

- **Squeezing them through a too-tight space** (e.g., in carpal tunnel syndrome, nerves to the hand are squeezed at the wrist)

What Does Neuropathy Feel Like?

“After 17 years of dialysis, my nerve damage comes in two flavors. One if I’ve been walking or standing for about 15 to 20 minutes it feels like my feet are falling asleep—pins and needles. This goes on until I sit down, but I put up with it because I have ‘places to go, people to see.’ The other thing I get is hot feet—this strikes more randomly.

I think taking B vitamins may help. I take them and dialyze daily, yet I have neuropathy, but after 18 years of ESRD, who’s to say if it would be worse if I had run less or didn’t take vitamins? I’ve always taken a prescribed renal vitamin. I’d for sure talk to your doc about thiamine or B’s in general. Why not take B’s? They’re pretty cheap but insurance won’t pay for them (at least mine won’t).”

—Bill,

“My feet don’t itch, but boy, do they burn! Yes, they do. They burn, as if I was standing on the very doorstep of hell and just ‘itching’ to go in. The thing that I find gives most relief is standing on a cold floor, but as this can become tiresome after the first couple of hours, I have rescued a spare stone tile left over from a kitchen redo and keep this at the foot of my armchair and plonk my bare tootsies on it. This helps a bit.” —Bob

- **Immune disease** that attacks the nerves
- **Poor blood flow** – this is more likely in the legs and feet, but may happen in the hands
- **Infection** – such as shingles
- **Diabetes** – half of people with diabetes have some degree of nerve damage
- **Poisons** – like lead or mercury

Nerve damage can change sensation, so soft fur might feel prickly to you. Or, you may have nerve damage *without* any symptoms. It can take years to feel the damage.

Dialysis and nerves

Neuropathy in people on dialysis is quite common—from 60% to 100% may have it. Why? In one study, more active nerves were found right *after* an HD treatment. Toxins that build up in the blood may poison the nerves.

We don’t know which toxins are to blame. One clue points to potassium. Studies have found that high potassium levels slow nerve function. Another middle molecule may also be at fault: TNF alpha has been found in higher levels in people on PD who have nerve damage than in those who don’t.

Symptoms of neuropathy

You may or may not have any symptoms of nerve problems. Here is a list you can show to your doctor. Check all that apply:

- **Tingling**
 - I have “pins and needles” in my hands and/or feet.





❑ Pain

- I have stabbing or shooting pains in my hands and/or feet.
- My hands or feet feel like they are burning.
- My feet are very sensitive to touch (e.g., the covers on at night).
- My feet hurt at night.
- My hands and/or feet get very hot or cold.

❑ Numbness or weakness

- My feet are numb.
- I don't feel any pain in my feet, even when I have a sore.
- I can't feel my feet when I walk.
- The muscles in my feet and legs are weak.
- The muscles in my hands or feet have shrunk or wasted away.
- I have foot drop (have a hard time lifting my toes when I walk).
- I am unsteady when I walk or stand.
- I can't feel heat or cold in my hands and/or feet.

❑ Other

- It seems like the muscles and bones in my feet have changed.
- It feels like I am walking on marbles.
- I have open sores on my feet and legs that heal slowly.
- (For men only) I have trouble getting an erection.

If you have any symptoms, be sure to tell your health care team about them. Some can be caused by other health problems, so you'll need to be checked by a doctor to be sure. Knowing about neuropathy is the first step to doing something about it. Read on, and we'll talk about preventions and treatments next.

Neuropathy? Protect Your Feet

If you have neuropathy, it is vital to check your feet each day, because you may not feel a blister or sore. Without treatment, these small injuries can become ulcers that won't heal, and can lead to the loss of a toe, foot, or leg.

Even if you can't *feel* your feet, you can still protect them. Here's how:

- Wear comfortable, well-fitting shoes and socks *all the time—even indoors*.
- Keep your feet clean and dry them well after you bathe or shower.
- Each bedtime, use a mirror to see the bottoms of your feet.
- Look for blisters, sores, cuts, or breaks in the skin.
- Be sure to look between your toes.
- Use your hands to feel for hot or cold spots, bumps, or dry skin.
- Check for calluses, red areas, swelling, ingrown toenails, and toenail infections.
- Use lotion to soothe dry feet.
- See a podiatrist to cut your toenails and remove calluses, especially if you have diabetes.
- Never use a razor on your feet (i.e., during a pedicure).

If you find *any* problems, call your doctor for treatment right away. Early treatment can keep a small problem from becoming a much bigger one later.





Preventing neuropathy

Clearly, the best defense is a good offense. You are best off if you can avoid nerve damage. Research shows that *neuropathy mainly happens when the GFR (the amount of filtering) is less than 12 mL/min*. Another study found that it was more likely the longer someone was on standard in-center HD—and the lower the dose of treatment. Men had more problems than women, perhaps because they are larger and need more blood cleaning.

These findings mean you may be able to prevent nerve damage by getting your blood cleaner with:

- Two dialyzers in sequence (this is not common practice, but can be done with some machines)
- Daily HD
- Nocturnal HD

B Vitamins Really Count!

Here's one patient's story of adding B vitamins:

"I was having foot numbness and burning, which I thought was neuropathy from being on dialysis for so long. The resident said it was beri beri (thiamine...vitamin B1) deficiency. She prescribed B1, and within a week...my feet felt fine. I had never seen this in any of the kidney education, though when I looked up thiamine deficiency, one of the causes is loss of thiamine from dialysis. I knew my B12 was being depleted; should have been a little quicker on the ball about the B1, as all the B vitamins are water soluble and are getting removed during treatment." —Debbie

Two other steps may also help you avoid neuropathy:

- 1 **Prevent vitamin deficiencies.** Dialysis removes B vitamins. Ask your dietitian what foods you can eat that are rich in B vitamins. If you don't take a renal vitamin with thiamine (B1), B6, and other B's, ask your doctor or dietitian to suggest one. It is best taken after dialysis, because the treatment can remove it.
- 2 **Prevent mineral deficiencies.** Dialysis also removes zinc. In a random, double-blind, crossover study, adding zinc to dialysate helped nerve function—and sense of taste. Before you take zinc or *any* supplement, talk with your nephrologist and your dietitian. There is a risk that any drug or herb could build up to toxic levels.

If you have diabetes, keeping your blood sugar in the target range can also help you prevent nerve damage. Ask your doctor to refer you to a certified diabetes educator (nurse and/or dietitian). They have extra training in diabetes care and can teach you to manage your diabetes.

Treating neuropathy

Once nerve damage occurs, you may need to try a number of things to get relief from the pain and numbness. Some options are listed below. Check the ones that you want to talk with your doctor about:

- **Get more dialysis** – Even if you have nerve damage symptoms, getting your blood cleaner may help keep them from getting worse. And, it may even help them to get a bit better.
- **Relieve pressure** – If you have carpal tunnel syndrome (a nerve problem), you may need surgery to free up space in your wrists for your nerves to fit.





- ❑ **Treat vitamin deficiencies** – Dialysis removes vitamin B6. Taking B6 helped relieve nerve pain in people on PD and on HD. If you don't take a renal vitamin, ask your doctor or dietitian to suggest one.

Pain control for neuropathy

A number of drugs—and non-drug approaches—have been used to treat nerve pain. Some of these can have side effects and it can take time to find one that helps you. Below are some drugs and non-drug treatments that the Mayo Clinic suggests. Check the ones you want to talk to your doctor about:

- ❑ **Over-the-counter pain pills** – If your symptoms are mild, acetaminophen (e.g., Tylenol®) or an NSAID (e.g., Motrin®, Aleve®, Advil®) may help. NSAIDs can reduce your remaining kidney function and cause stomach bleeding.
- ❑ **Antidepressants** – Low doses of some tricyclic or SSRI antidepressants can help pain (and sleep problems) along with depression. Some of these drugs may cause thoughts of suicide. Tell your doctor if you start thinking of harming yourself so he or she can switch you to a different drug.
- ❑ **Capsaicin cream** – Products made with the substance that gives chili peppers their heat can help nerve pain. You rub them on the skin (keep the cream away from your eyes).
- ❑ **Lidocaine patch** – If your pain is mostly in one place, a skin patch with a topical anesthetic may help. You may need to use a new patch up to three times per day.
- ❑ **Anti-seizure drugs** – Some drugs in this class, such as Neurontin® (gabapentin), Requip® (ropinirole HCl), Tegretol®



(carbamazepine), Dilantin® (phenytoin), and Lyrica® (pregabalin) may help relieve some nerve pain. These drugs are very strong and have many side effects. Dosage may be less in dialysis patients.

- ❑ **Prescription pain pills** – Opiate drugs like codeine, morphine, or oxycontin may ease pain, but can cause addiction.
- ❑ **Other drugs** – A heart rhythm drug called Mexitil® (mexiletine HCl) may help burning pain. This drug can worsen heart failure.

A New Option for Diabetic Neuropathy: Alpha-Lipoic Acid (ALA)

Research has found that the antioxidant supplement ALA can reduce the pain of diabetic neuropathy. A study of six randomized, controlled studies of ALA found that it significantly reduced nerve pain at doses of 600 mg/day.

In the U.S., ALA may be found as a pill, capsule, or softgel. As always, talk with your doctor before taking any supplement or over-the-counter pill.



Module 16 – Long-term Effects of Dialysis

- ❑ **Relaxation** – Tensing your muscles can make your pain worse. A gentle form of yoga, Tai Chi, meditation, or guided imagery may help you learn to relax.
- ❑ **Acupuncture** – Very thin needles are used to stimulate vital energy in the body. You may



need a few treatments, and they can be costly. Some health plans cover acupuncture.

- ❑ **Hypnosis** – While you are in a light trance, you are given suggestions to help you feel less pain. You can be taught to hypnotize yourself.
- ❑ **TENS** – A small machine sends electrical pulses to help block the path of nerve pain through your skin. It is safe and painless and may help.

Neuropathy is common in dialysis, but you can take steps to prevent it or to treat it if it happens. Talk with your doctor to be sure you are doing all you can to keep your nerves healthy.

Whether you are looking down the road and doing what you can to protect yourself, or you are dealing with long-term problems caused by dialysis, we hope you have found some help in this module. Knowledge is power! Making informed choices about your health can improve your quality of life and help you live more fully.





Personal Plan for _____

Long-term Effects of Dialysis

I want to take good care of myself, because I am looking forward to:

Heart failure

Fluid in my body is found in three “spaces”:

- ❶ Inside my cells
- ❷ Between my cells
- ❸ In my bloodstream

Only fluid that is in my bloodstream can be removed by dialysis. On a day-to-day basis, how well I feel depends on how fluid is removed.

Left ventricular hypertrophy (LVH) is a common heart problem in people on dialysis. The best way to avoid it is to keep my blood pressure in control by keeping fluid levels in my body as close to normal as possible all the time. I can do this by:

I will also ask my doctor about these tests:

If tests show that I have LVH, some things I can do are:

- Quit smoking
- Eat enough protein
- Ask about ARBs and ACE inhibitors
- Get bone disease treated
- Get more dialysis

Removing toxins with dialysis

Besides removing fluid, dialysis also removes toxins, including:

- Small molecules (easy to remove)
- Middle molecules (larger, and harder to remove with standard in-center treatment)
- Large molecules (even harder to remove)

Keeping my residual kidney function will help my dialysis remove more toxins. I can do this by:

- Quitting smoking, if I smoke
- Keeping my blood pressure in the target range my doctor gave me
- Keeping my blood sugar in the target range, if I have diabetes
- Protecting my kidneys from X-ray contrast dye
- Avoiding non-steroidal pain pills (called NSAIDs)
- Asking my kidney doctor before I take any herbs
- Asking about a new drug before I take it

Renal osteodystrophy

Renal osteodystrophy occurs when too much calcium is pulled from my bones over a long period of time.



Personal Plan for _____

(continued)

This can cause my bones to become weak and brittle. Common symptoms of renal osteodystrophy include:

- Joint pain
- Bone pain
- Bone fractures

Healthy kidneys keep my bone minerals in balance, including:

- Calcium – the most common mineral in my body (level should be 8.8 to 9.5 mg/dL)
- Phosphorus – a very common mineral found in most foods (level should be 3.5 to 5.5 mg/dL)
- Calcium-phosphorus product (Ca x P) (level should be less than 55)

I can help keep my bone minerals in balance by:

- Eating fewer high-phosphorus foods
- Taking phosphate binders with each meal and snack if they are prescribed for me
- Getting more dialysis, if possible

Treatment for renal osteodystrophy may include:

- Phosphate binders
- Active vitamin D (calcitriol) by mouth or through a vein
- A drug called Sensipar® (cinacalcet hydrochloride)
- Surgery to remove most of the parathyroid glands

Amyloidosis

Dialysis-related amyloidosis (DRA) is a common problem that can occur in dialysis when the protein

beta-2-microglobulin (B₂m) builds up in joints, tendons, and around bones. DRA can lead to:

- Arthritis-like pain
- Joint damage
- Bone cysts that can lead to fracture
- Carpal tunnel syndrome (wrist pain, numbness, and tingling)

Two main ways to prevent DRA are:

- 1 Choose a treatment that removes more B₂m
- 2 Use ultrapure water for hemodialysis

If DRA is present, treatments for symptom relief include steroid injections, pain pills, physical therapy, surgery, switching to a type of dialysis that removes more B₂m, or kidney transplant.

Neuropathy

Nerve damage (neuropathy) can change sensation, causing pain, numbness, burning, or tingling. From 60% to 100% of people on dialysis have some degree of nerve damage. I will talk with my doctor about these symptoms, which might be due to neuropathy:

And I want to ask my doctor about these options for neuropathy pain relief:





Take the Kidney Quiz!

You'll see how much you're learning if you take our quick kidney quiz. It's just 9 questions. How about it? (*Answers are on page 16-2.*)

- 1. From one day to the next, how well you feel on dialysis depends most on:**
 - a) How many vegetables you eat
 - b) How many books you read
 - c) How much fluid is removed and how quickly
 - d) How many toxins are removed
- 2. The best way to avoid a common dialysis heart problem called left ventricular hypertrophy (LVH) is to:**
 - a) Get regular chest X-rays
 - b) Keep your blood pressure in the target range
 - c) Exercise each day for at least 30 minutes
 - d) Practice deep breathing and meditation
- 3. Middle molecules can cause long-term problems on dialysis because:**
 - a) They are harder to remove and can build up in the body, causing damage
 - b) They are sticky and can gum up your organs
 - c) They move quickly and zigzag around inside the dialyzer, causing leaks
 - d) They block removal of small molecules that are used to measure adequacy
- 4. The two most important bone minerals in your body are:**
 - a) Zinc and sodium
 - b) Iron and magnesium
 - c) Calcium and phosphorus
 - d) Potassium and copper
- 5. What disease can occur when your body makes too much parathyroid hormone?**
 - a) Multiple sclerosis
 - b) Freezer burn
 - c) Psoriasis
 - d) Renal osteodystrophy
- 6. Healthy kidneys make _____, which helps you absorb calcium from foods you eat:**
 - a) Calcitriol
 - b) Carpal tunnel syndrome
 - c) Carbonate
 - d) Citrate
- 7. Amyloidosis, a common long-term dialysis bone and joint problem, may be preventable with:**
 - a) Showers and antibacterial soap
 - b) Weekly swimming and whirlpool tubs
 - c) Better dialysis chairs and vitamin D
 - d) More dialysis and ultrapure water
- 8. If you have nerve damage (neuropathy) from kidney failure, it is important to check your feet each day because:**
 - a) You might not feel an injury when it happens
 - b) You could have a blister or sore without knowing it
 - c) Early treatment for a foot injury can save your limb
 - d) All of the above
 - e) None of the above
- 9. Which of the following is NOT a treatment for neuropathy?**
 - a) A TENS unit
 - b) Medication
 - c) Ice
 - d) B vitamins



Additional Resources

Besides the free Life Options materials you can find at www.lifeoptions.org, the resources below may help you learn more about the topics in this module of Kidney School.

PLEASE NOTE: Life Options does not endorse these materials. Rather, we believe you are the best person to choose what will meet your needs from these or other resources you find. Please check with your local library, bookstore, or the internet to find these items.

Materials:

- 1 ***Help, I Need Dialysis!*** by Dori Schatell, MS, and Dr. John Agar
(Medical Education Institute, 2012, http://www.lifeoptions.org/help_book, ISBN-13: 978-1937886004)
Easy to read, fully referenced book covers the lifestyle impact of each type of dialysis—including information on long-term effects and survival for each form of dialysis.
- 2 ***Amyloidosis and Kidney Disease***, by the National Kidney and Urologic Diseases Information Clearinghouse (NKUDIC). To learn more, please call (800) 891-5390, e-mail nkudic@info.niddk.nih.gov, or visit their website kidney.niddk.nih.gov/kudiseases/pubs/amyloidosis/index.htm.
- 3 ***National Nutrient Database***, by the USDA. This database has nutrient lists for foods and you can look for calcium, phosphorus, thiamine, B vitamins, etc. Lists are in alphabetical order or by nutrient content from highest to lowest. Visit www.ars.usda.gov/Services/docs.htm?docid=9673.
- 4 ***Prevent Diabetes Problems: Keep Your Nervous System Healthy***, by the National Diabetes Information Clearinghouse (NDIC). To learn more, please call (800) 860-8747, e-mail ndic@info.niddk.nih.gov, or visit diabetes.niddk.nih.gov/dm/pubs/complications_nerves/index.htm.
- 5 ***Renal Osteodystrophy***, by the National Kidney and Urologic Diseases Information Clearinghouse (NKUDIC). To learn more, please call (800) 891-5390, e-mail nkudic@info.niddk.nih.gov, or visit kidney.niddk.nih.gov/kudiseases/pubs/renalosteodystrophy/index.htm.

