



Kidney Failure and the Kidney Failure Risk Equations (KFRE)

WHAT IS KIDNEY FAILURE?

Kidney failure happens when your kidneys stop working. At this point, you need to choose a treatment that replaces lost kidney function, such as dialysis or kidney transplant. Or, you may choose medical care alone, without dialysis or transplant. You may also choose no treatment.

WHAT ARE THE KIDNEY FAILURE RISK EQUATIONS (KFRE)?

The KFRE are math equations that can predict how high or low your chance (risk) is for reaching kidney failure within the next 2-year and 5-year points in time. Results are given as a percent (%) on a scale of less than 1% to 99.99%. For example, a result of 1% chance of reaching kidney failure within 2 years, with a 5% chance at 5 years, is considered low.

The KFRE use specific information about you and your health called **variables**. Some variables such as **age** and **gender** can't be changed, so they're called *non-modifiable* variables.

However, other variables such as **phosphorus** and urine albumin-to-creatinine ration (UACR) can be improved to lower your chances of reaching kidney failure, or to prolong the time it takes to reach kidney failure. These variables are modifiable because they can improve with the right care.

By studying the health information of more than 700,000 patients with chronic kidney disease (CKD) in 30 countries around the world, experts found which variables increase a person's chances for reaching kidney failure. These variables are listed below. By clicking a variable, you'll be taken to a page with more information about how it fits into the KFRE and how it might be improved to lower your chances of reaching kidney failure, or at least prolong the time it takes to reach kidney failure.

1. Age
2. Gender
3. Estimated glomerular filtration rate (eGFR)
4. Urine albumin-to-creatinine ratio (UACR)
5. Serum bicarbonate
6. Serum albumin
7. Serum phosphorus
8. Serum calcium

There are 2 KFRE. The *4 variable equation* uses the first four variables only, and the *8 variable equation* uses all eight. Your doctor and healthcare team use only your personal variables to calculate your individual risk for kidney failure using one of these equations.





Kidney Failure and the Kidney Failure Risk Equations (KFRE)

WHY IS PREDICTING MY RISK FOR KIDNEY FAILURE HELPFUL?

Rather than waiting for kidney failure to strike without warning, it's much better for your health if you can predict how great a chance you have for developing it in the future. This knowledge helps you be as well prepared as possible.

On the other hand, this knowledge could put you at ease because your risk for kidney failure is lower than you thought. You may find that even though you have CKD, your risk for reaching kidney failure in your lifetime is very low. In fact, only 3% of patients with CKD reach kidney failure.

But if you are at high risk for reaching kidney failure, then you'll have time to take better care of yourself. This could possibly slow down the progression of your CKD and help you delay the need for dialysis or a transplant.

And finally, if you do need treatment for kidney failure within 2 to 5 years, then you'll have time to consider your treatment options. Predicting when you might be reaching kidney failure allows you and your healthcare team to prepare and make the best decisions possible regarding your care. Treating kidney failure requires adequate time for careful planning based on your personal goals and individual state of health.

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Age

AND YOUR KIDNEYS



Why is age used as a risk factor to predict your chances of reaching kidney failure?

You might think that older age would increase your chance of reaching **kidney failure** sooner than someone younger. But studies on large numbers of people with **chronic kidney disease (CKD)** have shown that *younger* age may predict a faster time to reaching kidney failure.

This may be due to having CKD starting at a younger age, so that kidney failure happens sooner in life. Or as people get older, they're more likely to die from another problem like heart disease before they ever have a chance to reach kidney failure.

Also, patients in certain studies were counted as having kidney failure only if they were on **dialysis** or had a **kidney transplant**. These patients may have been younger than older patients who did not get either of these treatments. Therefore, older patients with kidney failure may not have been counted.

But no matter our age, we need to take good care of our kidneys. Kidney failure can happen at any age.

HOW DOES OLDER AGE AFFECT MY KIDNEYS?

Aging is a normal and natural process that affects all parts of the body, including the kidneys. But over time, our kidneys change in the way they look and in the way

they work. Just as we see wrinkles and age spots on our skin, so too do the kidneys show changes that can be seen with a microscope.

The kidneys have tiny filters called nephrons that clean all the blood in our body. We're born with about a million of these units in each kidney. But as we get older, we lose some nephrons, and some other nephrons might not work as well as when younger.

Loss of nephrons will affect the **estimated glomerular filtration rate (eGFR)**, a blood test that shows our level of kidney function (how well our kidneys are working). **Please note that a decline in kidney function is normal as we get older and may not always be a sign of kidney disease.**

Having less nephrons and less kidney function makes it harder for the kidneys to handle stress. For example, diseases such as diabetes and high blood pressure place more stress on older kidneys. The effects of this stress are greater for older kidneys and can cause more kidney damage than in younger kidneys.

Older kidneys also have more chance to suffer from **acute kidney injury (AKI)**. AKI is kidney damage that happens very quickly. It happens because of problems like using too high a dose of a certain drug, or not drinking enough fluid on a very hot day.

Why is age used as a risk factor to predict your chances of reaching kidney failure?



WHAT CAN YOU DO TO PROTECT YOUR KIDNEYS AT ANY AGE?

- Get your kidneys checked at least every year. Your healthcare team will do a simple blood test to find out your eGFR. They will also do a urine albumin-to-creatinine ratio (UACR), which shows if you have protein (albumin) in the urine. Protein in the urine may mean you have kidney damage.
- Control blood pressure if you have high blood pressure.
- Control blood sugar if you have diabetes.
- In general, if you have CKD, avoid non-steroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen and naproxen.
- If you have CKD, tell your healthcare team before having any test that uses contrast dye.
- Do not smoke.
- Exercise and follow a healthy diet that's low in sodium, saturated fat, and sugar, but high in fresh fruits, vegetables, whole grains, lean meats, fish, and poultry. Avoid highly processed foods.
- Stay at a healthy weight. Lose weight if your healthcare team says that you should.
- Discuss any vitamins, minerals, herbs, weight loss or body building supplements with your healthcare team before taking them. Many of these products can hurt your kidneys.
- Make sure that any **drugs** you take are the right dose for your age and your level of kidney function. You should discuss this with your healthcare team.

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Gender

AND YOUR KIDNEYS



Why is gender used as a risk factor to predict your chances of reaching kidney failure?

Studies show that although more women than men have **chronic kidney disease (CKD)**, men are more likely to reach **kidney failure** sooner than women. That's why being male is used as a risk factor to predict a faster time to reach kidney failure.

The reasons for these gender differences are not clearly understood. Women may be more likely to have CKD because of getting urinary tract infections more often, which can lead to kidney damage. Women also have increased risk for kidney damage due to problems with pregnancy, such as high blood pressure or eclampsia.

Men may be at increased risk of reaching kidney failure sooner than women because of differences in hormone levels. Higher testosterone levels in men may

cause a loss in kidney function. On the other hand, men's kidneys may not be protected by estrogen, which is higher in women until menopause.

Overall, men may have unhealthier lifestyles, thereby leading to a higher risk for kidney failure. And in studies, men may have been counted as having kidney failure at a younger age than women because they may have gotten dialysis or a kidney transplant sooner than women. Although more women may have had kidney failure, they may not have been counted in studies because they weren't on dialysis or didn't have a kidney transplant.

No matter our gender, we need to take good care of our kidneys. Kidney failure can happen to anyone.



Why is gender used as a risk factor to predict your chances of reaching kidney failure?

WHAT CAN MEN AND WOMEN DO TO PROTECT THEIR KIDNEYS?

WOMEN

- Get good prenatal care and start as early as possible.
- Treat urinary tract infections right away.
- If you have CKD, know which types of birth control may harm your kidneys, and which types of drugs are safe to use when you are pregnant.

MEN

- Check with your healthcare team to know if any prostate or hormone treatments can hurt your kidneys.
- If you have an enlarged prostate, ask your healthcare team if it is causing a blockage in your urinary tract.

EVERYONE

- Get your kidneys checked at least every year. Your healthcare team will do a simple blood test to find out your **eGFR**. They will also do a **urine albumin-to-creatinine ratio (UACR)**, which shows if you have protein (albumin) in the urine. Protein in the urine may mean you have kidney damage.

- Control blood pressure if you have high blood pressure.
- Control blood sugar if you have diabetes.
- In general, if you have CKD, avoid non-steroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen and naproxen.
- If you have CKD, tell your healthcare team before having any test that uses contrast dye.
- Do not smoke.
- Exercise and follow a healthy diet that's low in sodium, saturated fat, and sugar, but high in fresh fruits, vegetables, whole grains, lean meats, fish, and poultry. Avoid highly processed foods.
- Stay at a healthy weight. Lose weight if your healthcare team says that you should.
- Discuss any vitamins, minerals, herbs, weight loss or body building supplements with your healthcare team before taking them. Many of these products can hurt your kidneys.
- Make sure that any drugs you take are the right dose for your age and your level of kidney function. You should discuss this with your healthcare team.

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eGFR

AND YOUR KIDNEYS









What is the eGFR?

The **estimated glomerular filtration rate (eGFR)** is a test that measures your level of kidney function and determines your stage of kidney disease. Your healthcare team can calculate it from the results of your blood **creatinine** test, your age, body size, and gender. If your eGFR number is low,

your kidneys may not be working as well as they should. People with a lower eGFR are at increased risk of having **chronic kidney disease (CKD)** progress to kidney failure. The sooner that kidney disease is found, the better the chance of slowing or stopping it from getting worse.

WHAT ARE THE STAGES OF CHRONIC KIDNEY DISEASE (CKD) THAT MATCH eGFR LEVELS?

| STAGES OF CHRONIC KIDNEY DISEASE | | GFR* | % OF KIDNEY FUNCTION |
|----------------------------------|--|--------------|---|
| Stage 1 | Kidney damage with normal kidney function | 90 or higher |  90-100% |
| Stage 2 | Kidney damage with mild loss of kidney function | 89 to 60 |  89-60% |
| Stage 3a | Mild to moderate loss of kidney function | 59 to 45 |  59-45% |
| Stage 3b | Moderate to severe loss of kidney function | 44 to 30 |  44-30% |
| Stage 4 | Severe loss of kidney function | 29 to 15 |  29-15% |
| Stage 5 | Kidney failure | Less than 15 |  Less than 15% |

* Your GFR number tells you how much kidney function you have. As kidney disease gets worse, the GFR number goes down.



What is the eGFR?

WHAT DOES AN EGFR TEST RESULT MEAN?

- An eGFR below 60 for three months or more, or an eGFR above 60 with kidney damage (marked by high levels of **albumin** in your urine) means chronic kidney disease. Your healthcare team will want to find the cause of your kidney disease and continue to check your kidney function to help plan your treatment.
- Please note that the eGFR normally declines with age. A low eGFR in an older person does not always mean CKD, even if the eGFR is less than 60.
- When you get an eGFR test, a simple urine test called the **UACR** will also be done to check for blood or albumin (a type of protein) in the urine. When you have albumin in your urine it is called **albuminuria**. Blood or protein in the urine can be an early sign of kidney disease.

BASED ON YOUR EGFR AND UACR, YOUR HEALTHCARE TEAM MAY ALSO DO ONE OR MORE OF THESE TESTS:

- Imaging, such as an ultrasound or CT scan to get a picture of your kidneys and urinary tract. This tells your healthcare team whether your kidneys are too large or too small, whether you have a problem like a kidney stone or tumor, and whether there are any problems in the structure of your kidneys and urinary tract.
- A **kidney biopsy**, which is done in some cases to check for a specific type of kidney disease. This test shows the type and amount of kidney damage there is, which helps with planning treatment. To do a biopsy, the doctor removes small pieces of kidney with a needle and looks at them under a microscope.

Your healthcare team may also ask you to see a kidney doctor, called a nephrologist, who will consult on your case and help manage your care.

WHAT CAN YOU DO TO PROTECT YOUR KIDNEY FUNCTION?

- Get your kidneys checked at least every year. Your healthcare team will do a simple blood test to find out your eGFR. They will also do a urine **albumin-to-creatinine ratio (UACR)**, which shows if you have protein (albumin) in the urine. Protein in the urine may mean you have kidney damage.
- Control blood pressure if you have high blood pressure.
- Control blood sugar if you have diabetes.
- In general, if you have CKD, avoid non-steroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen and naproxen.
- If you have CKD, tell your healthcare team before having any test that uses contrast dye.
- Do not smoke.
- Exercise and follow a healthy diet that's low in sodium, saturated fat, and sugar, but high in fresh fruits, vegetables, whole grains, lean meats, fish, and poultry. Avoid highly processed foods.
- Stay at a healthy weight. Lose weight if your healthcare team says that you should.
- Discuss any vitamins, minerals, herbs, weight loss or body building supplements with your healthcare team before taking them. Many of these products can hurt your kidneys.
- Make sure that any drugs you take are the right dose for your age and your level of kidney function. You should discuss this with your healthcare team.

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UACR

AND YOUR KIDNEYS

Urine Albumin-To-Creatinine Ratio (UACR)

WHAT IS THE UACR?

The **urine albumin-to-creatinine ratio (UACR)** shows whether you have albumin in your urine. Albumin is a type of protein that's normally found in the blood.

Your body needs protein. It's an important nutrient that helps build muscle, repair tissue, and fight infection. But it should be in your blood, not your urine. When you have albumin (protein) in your urine, it is called *albuminuria* or *proteinuria*.

One of the main jobs of your kidneys is to filter your blood. Your kidneys keep important things your body needs inside your blood, like protein. They also remove things your body doesn't need, like wastes and extra water.

If kidneys are healthy, they should let only very little protein go into your urine – or even none. But if your kidneys are damaged, protein can “leak” out of the kidneys into your urine. People with a high amount of albumin in their urine are at an increased risk of having chronic kidney disease progress to kidney failure.

HOW IS THE UACR TESTED?

The UACR is a simple urine test that's part of a routine exam. Only a small amount of your urine is needed (about two tablespoons) to do the test. Your urine will be sent to a lab. Blood or protein in the urine may be a sign of kidney disease.

| Albuminuria categories | | |
|----------------------------|-----------------------------|--------------------------|
| A1 | A2 | A3 |
| Normal to mildly increased | Moderately increased | Severely increased |
| <30 mg/g <3 mg/mmol | 30-300 mg/g 3-29 mg/mmol | ≥300 mg/g ≥30 mg/mmol |

| GFR Stages | G1 | Normal or high | ≥90 | | | |
|------------|-----|----------------------------------|-------|--|--|--|
| | G2 | Mildly decreased | 60-90 | | | |
| | G3a | Mildly to moderately decreased | 45-59 | | | |
| | G3b | Moderately to severely decreased | 30-44 | | | |
| | G4 | Severely decreased | 15-29 | | | |
| | G5 | Kidney failure | <15 | | | |

Key to Figures:

Colors: Represents the risk for progression, morbidity and mortality by color from best to worst.

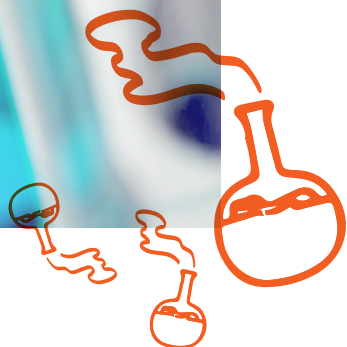
Green: Low Risk (if no other markers of kidney disease, no CKD)

Yellow: Moderately Increased Risk

Orange: High Risk

Red: Very High Risk

Deep Red: Highest Risk



When you get a UACR test, a simple blood test called the *estimated glomerular filtration rate (eGFR)* will also be done. Your eGFR shows how well your kidneys are working.



Urine Albumin-To-Creatinine Ratio (UACR)

WHAT DOES THE UACR TEST RESULT MEAN?

A normal amount of albumin in your urine is less than 30 mg/g. Anything above 30 mg/g may mean you have kidney disease, even if your **estimated glomerular filtration (eGFR)** number is above 60.

A high UACR may be an early sign of kidney disease, but your healthcare team will check you again to make sure albuminuria is not caused by something else. If your healthcare team thinks you may have kidney disease, the UACR will be done again. Three high results for three months or more is a sign of kidney disease.

Based on your eGFR and UACR, your healthcare team may also do one or more of these tests:

- Imaging, such as an ultrasound or CT scan to get a picture of your kidneys and urinary tract. This tells your healthcare team whether your kidneys are too large or too small, whether you have a problem like a kidney stone or tumor, and whether there are any problems in the structure of your kidneys and urinary tract.

A kidney biopsy, which is done in some cases to check for a specific type of kidney disease. This test shows the type and amount of kidney damage there is, which helps with planning treatment. To do a biopsy, the doctor removes small pieces of kidney with a needle and looks at them under a microscope.

Your healthcare team may also ask you to see a kidney doctor, called a nephrologist, who will consult on your case and help manage your care.

WHAT CAN YOU DO TO DECREASE OR STOP ALBUMINURIA?

- Your healthcare team will most likely prescribe a special type of blood pressure medicine that can help decrease or stop you from losing albumin in your urine. There are 2 types of this medicine. One is an **ACEi (angiotensin converting enzyme inhibitor)** and the other is an **ARB (angiotensin**

receptor blocker). Even if you have normal blood pressure, you may still be told to take one of these types of medicine.

- You should follow a diet that is low in salt and sodium. This type of diet helps the blood pressure medicine work even better.

WHAT ELSE CAN YOU DO TO PROTECT YOUR KIDNEY FUNCTION AND PREVENT KIDNEY DAMAGE?

- Get your kidneys checked at least every year. Your healthcare team will do a simple blood test to find out your eGFR. They will also do a urine albumin-to-creatinine ratio (UACR), which shows if you have protein (albumin) in the urine. Protein in the urine may mean you have kidney damage.
- Control blood pressure if you have high blood pressure.
- Control blood sugar if you have diabetes.
- In general, if you have CKD, avoid non-steroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen and naproxen.
- If you have CKD, tell your healthcare team before having any test that uses contrast dye.
- Do not smoke.
- Exercise and follow a healthy diet that's low in sodium, saturated fat, and sugar, but high in fresh fruits, vegetables, whole grains, lean meats, fish, and poultry. Avoid highly processed foods.
- Stay at a healthy weight. Lose weight if your healthcare team says that you should.
- Discuss any vitamins, minerals, herbs, weight loss or body building supplements with your healthcare team before taking them. Many of these products can hurt your kidneys.
- Make sure that any drugs you take are the right dose for your age and your level of kidney function. You should discuss this with your healthcare team.

Speak with your healthcare team



RISK FACTOR

Serum Phosphorus

AND YOUR KIDNEYS



What are phosphorus and serum phosphorus?

Phosphorus is an important mineral that's found in many foods. After we eat it, phosphorus goes mostly to our bones. We need to get phosphorus in the diet because our bodies can't make it.

Along with calcium, phosphorus is needed to build healthy bones and teeth. The remaining phosphorus is found throughout our bodies, where it is used to give us energy. This energy is very important for good muscle function, including the muscles that help us breathe.

Serum phosphorus is the phosphorus in our blood.

WHY IS HIGH SERUM PHOSPHORUS A RISK FACTOR FOR REACHING KIDNEY FAILURE?

Healthy kidneys can remove extra phosphorus in your blood. But when you have **chronic kidney disease (CKD)**, your kidneys can't remove phosphorus very well. Extra phosphorus causes body changes that pull calcium out of your bones, making them weak.

High phosphorus can also combine with calcium, leading to dangerous deposits in the blood vessels, lungs, eyes, and heart. Over time this can cause an increased risk for heart attack, stroke, or death.

Aside from these dangerous effects, studies have also shown that high phosphorus levels may directly harm the kidneys and cause a loss of kidney function. This loss of function increases the risk for kidney failure.

WHAT IS A SAFE LEVEL OF SERUM PHOSPHORUS?

A normal serum phosphorus level is 2.5 to 4.5 mg/dL. Even if you

have CKD, there are reasons why your phosphorus level may be too low, and you may need treatment for that. But in general, most CKD patients need to control their phosphorus level. Keep track of your phosphorus levels and discuss them with your healthcare team.

HOW CAN I CONTROL MY PHOSPHORUS LEVEL?

You can keep your serum phosphorus level normal through diet and medicine. A dietitian who works with kidney patients can help you plan a low phosphorus diet that fits your individual needs. Below are some basic facts about phosphorus in food.

Organic phosphorus is found naturally in many unprocessed protein-rich foods such as meats, poultry, fish, nuts, beans and dairy products. But the phosphorus in animal foods is absorbed more easily than the phosphorus in plant foods. Therefore, eating more plant-based protein like soy rather than animal-based protein like meat may be helpful in limiting your phosphorus intake.

Inorganic phosphorus that has been added to food as an additive or preservative is found in fast foods, ready-to-eat foods, canned and bottled drinks, enhanced meats, and most processed foods. Inorganic phosphorus is completely absorbed. Therefore, avoiding phosphorus additives can greatly lower your phosphorus intake. Phosphorus additives are listed on the nutrition facts label under "ingredients." Look for "PHOS" to find phosphorus additives in packaged foods.

What are *phosphorus and serum phosphorus*?

Phosphorus additives found in foods include:

- Dicalcium phosphate
- Disodium phosphate
- Monosodium phosphate
- Phosphoric acid
- Sodium hexameta-phosphate
- Trisodium phosphate
- Sodium tripolyphosphate
- Tetrasodium pyrophosphate

WHICH MEDICINES HELP CONTROL PHOSPHORUS LEVELS?

Your healthcare team may order a medicine called a **phosphate binder** for you to take with meals and snacks. This medicine will help control the amount of phosphorus your body absorbs from the foods you eat.

There are different types of phosphate binders. Pills, chewable tablets, powders, and liquids are available. Some types also have calcium, while others do not. You should only take the phosphate binder that is ordered by your healthcare team. Make sure that any drugs you take are the right dose for your age and your level of kidney function. You should discuss this with your healthcare team.

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What is serum albumin?

Serum albumin is the main protein that's found in our blood. It's made in our liver, but we need a very good diet with enough protein to make the right amount. The normal level of albumin in the blood is 3.5 g/dL to 5 g/dL.

Serum albumin has many important jobs. It acts like a magnet in the blood to keep fluid in the right place throughout your body. When it's too low, you may get swelling from the build up of fluid in your feet, ankles, hands, around your eyes, lower back, or other parts of your body.

Albumin also carries important substances throughout the body, like hormones and drugs. So when serum albumin is low, these important products can't get to where they are needed in your body.

Serum albumin can be low in the blood for these reasons:

- Liver disease
- Extra fluid in your blood due to problems like heart failure. This extra fluid makes your albumin level seem low, even though it may be normal.
- Poor nutrition
- Stress, which can cause inflammation throughout your body.
- Losing albumin in the urine

WHY DOES A LOW SERUM ALBUMIN INCREASE THE RISK FOR REACHING KIDNEY FAILURE?

Many studies have shown that **chronic kidney disease (CKD)** patients with a low serum albumin have an increased risk for reaching kidney failure as compared to patients with a normal serum albumin. The reasons for this are not completely understood, but experts have used studies to get an idea of why there's a link.

Some experts think that a low serum albumin is just a **marker** (type of sign in the blood) that shows the kidneys have been harmed. In other words, a low serum albumin only happens as a result of other underlying problems.

These underlying problems may include:

- Less albumin being made by the body and being broken down more quickly when nutrition is poor.
- Damaged kidneys that cause albumin to be lost in the urine, which is called **albuminuria**.



Serum
Albumin

AND YOUR KIDNEYS

What is serum albumin?

WHAT CAN I DO TO PREVENT OR FIX A LOW SERUM ALBUMIN LEVEL?

- Eat a well-balanced diet with the right amount of protein. But not only do you need enough protein from foods like eggs and nuts, you also need enough energy from carbohydrate foods like whole grain bread and rice.
- Control albuminuria. Your healthcare team may tell you to take a special type of blood pressure medicine, either an **ACEi (angiotensin converting enzyme inhibitor)** or an **ARB (angiotensin receptor blocker)**. You should also follow a diet low in salt and sodium.
- Control fluid build-up in your body. Your healthcare team may tell you to take a drug called a **diuretic** to remove extra fluid in your body. You should also follow a diet low in salt and sodium.
- Make sure that your healthcare team has checked your liver.
- Your healthcare team may tell you to take dietary supplements that give you extra protein and calories.
- Depending on the reason for your low serum albumin, your healthcare team may give you albumin through a needle in a vein (IV albumin).

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*Serum
Calcium*

AND YOUR KIDNEYS

What are *calcium* and *serum calcium*?

Calcium is a mineral stored mainly in your bones. But it's also found throughout the body, including the muscle and blood. You need to get calcium from your diet since the body can't make it.

Serum calcium is the calcium in your blood.

You need calcium for these important jobs:

- Form bones and teeth
- Make muscles move (muscle contractions), including the heart muscle
- Clot the blood to stop you from bleeding too much if you get a cut
- Help the heart keep a steady heart beat
- Help nerves work well

Calcium moves out of bones and into the blood when needed in order to keep serum calcium levels normal. If you don't eat enough calcium, then too much comes out of the bones. When too much calcium leaves the bones, bones get weak.

If serum calcium gets too low, then enough calcium can't go to nerves, muscles, and wounds. This can cause serious problems with the heart and other muscles, and with blood clotting.

WHY CAN SERUM CALCIUM BECOME LOW IN PEOPLE WITH KIDNEY DISEASE?

Our bodies can't make vitamin D. We can only get vitamin D from food and by exposing our skin to sunlight. Healthy kidneys can take that vitamin D we absorb and change it to an active form. That active vitamin D then helps us absorb calcium.

But in **chronic kidney disease (CKD)**, the kidneys are less able to make active vitamin D. Without enough active vitamin D, you absorb less calcium from the food you eat, so it then becomes low in your blood. Also, extra **phosphorus** in the blood of people with CKD may bind to calcium in the blood. This can then lower serum calcium.

A normal serum calcium level is 8.5 - 10.2 mg/dL. A serum calcium that is either too low or too high can be dangerous and both conditions need treatment. But patients with low serum calcium, even levels at the lower end of normal, have been found to reach kidney failure faster than people with higher serum calcium levels.

What are calcium and serum calcium?

WHY IS LOW SERUM CALCIUM A RISK FACTOR FOR REACHING KIDNEY FAILURE?

Studies on thousands of patients with CKD show a link between low serum calcium and a faster time to reaching kidney failure than patients with normal levels. Low serum calcium is also linked to low vitamin D levels caused by CKD. Therefore, low serum calcium may be a sign that vitamin D is too low because kidney function is getting worse and heading toward kidney failure.

WHAT CAN I DO TO KEEP MY SERUM CALCIUM LEVEL NORMAL?

Eat a well-balanced diet. Other nutrients such as magnesium and vitamin D are needed to absorb

calcium. A dietitian who works with kidney patients can help you plan a diet that fits your individual needs. Dairy foods are high in calcium, but may also be high in **phosphorus**, which is usually limited in CKD. Your dietitian can help you find healthy alternatives to many high phosphorus foods.

You may need a vitamin D supplement, but your healthcare team will need to order the right one for you. Don't take a vitamin D supplement or a calcium supplement unless your healthcare team orders one for you. If you need a medicine called a **phosphate binder** to lower your phosphorus, then your healthcare team may recommend one that has calcium.

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Serum Bicarbonate

AND YOUR KIDNEYS

What are bicarbonate and serum bicarbonate?

Bicarbonate is a substance called a **base**, which the body needs to help keep a normal acid-base (pH) balance. This balance prevents your body from becoming too acid, which can cause many health problems. The lungs and kidneys keep a normal blood pH by removing excess acid.

Serum bicarbonate mostly travels throughout the body as carbon dioxide (CO₂), a gas that's dissolved in the blood. That's why the amount of CO₂ in your blood is used to measure serum bicarbonate (base), and to therefore check your acid-base balance. If CO₂ is too low in your blood, then that means serum bicarbonate (base) is low, and your body has too much acid. Too much acid in the body is called **metabolic acidosis**.

WHAT CAUSES METABOLIC ACIDOSIS IN CHRONIC KIDNEY DISEASE (CKD)?

Healthy kidneys remove acid from the body through urine and they keep the right amount of bicarbonate (base) in the blood. But in CKD, the kidneys can't remove enough acid, which can lead to metabolic acidosis.

The normal level of serum bicarbonate is 22-29 mEq/L. Kidney experts recommend that patients not have their serum bicarbonate levels fall below 22 mEq/L.

WHAT ARE THE SIGNS AND SYMPTOMS?

Not everyone will have signs or symptoms. However, you may have:

- Long and deep breaths
- Fast heartbeat
- Headache and/or confusion
- Weakness
- A feeling of being very tired
- Vomiting and/or feeling sick to your stomach (nausea)
- Loss of appetite

If you experience any of these, it's important to let your healthcare team know right away.

What are bicarbonate and serum bicarbonate?

WHAT ARE THE HEALTH PROBLEMS FROM METABOLIC ACIDOSIS IN CKD OR KIDNEY FAILURE?

- **Increased bone loss (osteoporosis):** Metabolic acidosis can cause a loss of bone in your body. This can lead to a higher chance of fractures in important bones like your hips or backbone.
- **Decreased growth in children:** Metabolic acidosis prevents the release of growth hormone, which is needed for proper growth.
- **Progression of CKD:** As acid builds up, kidney function decreases. And as kidney function decreases, more acid builds up to cause more kidney damage. This makes CKD worse.
- **Muscle loss:** Excess acid in the body causes muscles to break down, which is called “muscle wasting.”
- **High blood sugar:** Excess acid can cause your body to resist the effects of insulin, the hormone in your body that helps keep your blood sugar level from getting too high.
- **Death:** Studies have shown a link between metabolic acidosis and an increased risk for death.

WHY DOES A LOW SERUM BICARBONATE INCREASE THE RISK OF REACHING KIDNEY FAILURE?

Studies on thousands of patients with a low serum bicarbonate showed that they reached kidney failure faster than patients with a normal serum bicarbonate. The reasons for this are not very clear, but excess acid may not only harm the kidneys directly, but it may also make diseases like high blood pressure and diabetes worse. These two diseases are the main causes of CKD, so making them worse could make kidney failure happen more quickly. Other diseases that are common in CKD, such as heart disease and gout, are also made worse by metabolic acidosis and can therefore make patients reach kidney failure faster than patients who do not have these diseases.

HOW IS METABOLIC ACIDOSIS TREATED?

Studies have shown that treatment with sodium bicarbonate (baking soda) or sodium citrate pills, which are base substances, can help keep kidney disease from getting worse. However, you should not take sodium bicarbonate or sodium citrate pills unless your healthcare team recommends them. Another type of treatment that binds excess acid in the bowels is being studied for treating metabolic acidosis. You can discuss these treatment options with your healthcare team.

A diet that includes more plant-based proteins than animal-based proteins, along with a high intake of fruits and vegetables, can also help keep acid levels from rising in the blood. Before making any dietary changes, speak with your healthcare team.

Speak with your healthcare team

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