What I tell my patients about blood and urine tests

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The most important thing the kidney does is get rid of waste products and excess water and salts through urine. Kidney diseases disrupt this, so that more waste products can be found in blood, and salt and water balance may be upset. However, the kidney does other important things too.

- It controls blood pressure – so this is often high in people with kidney diseases.
- It makes erythropoietin (EPO), which prevents anaemia.
- It excretes excess acid.

Here we explain the common blood and urine tests for people with kidney diseases. Table 1 lists all the tests that you may undergo, and shows you what these tests reveal about your kidney function.

Blood tests

Which tests will show how my kidneys are functioning?

Creatinine (creat) tests

These are the best routine blood tests for measuring how well your kidneys are working. Creatinine is produced by muscles and excreted by the kidneys. Because it is produced by muscles, there is more of it in muscular people, so that a big weightlifter with normal kidney function will have more creatinine in their blood than a small person with less muscle (Figure 1). Creatinine measurement methods vary, so the same blood samples may give slightly different results in two different labs.

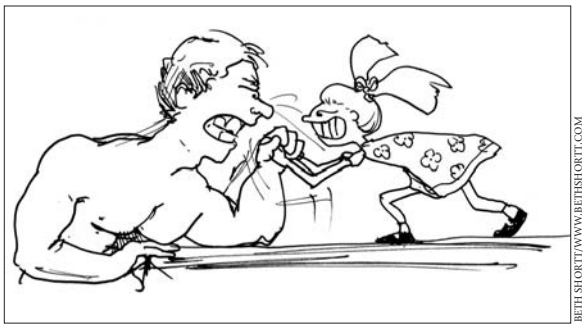

Figure 1. This body-builder has normal kidneys and a creatinine level of 120 µmol/l. The little girl has normal kidneys and a creatinine level of less than 60 µmol/l.

A problem with creatinine tests is that levels do not rise much in early kidney disease, and in people with little muscle they may be normal until 50% of kidney function is lost. Ways to get around this include using creatinine, together

Table 1. What is normal?

Test	Normal value	When kidneys fail
Creatinine	60–120 µmol/l	Goes up as kidney function goes down
Urea	2.5–6.6 mmol/l	Accumulates in blood in kidney failure
Potassium	3.6–5.0 mmol/l	Up to 6.0 mmol/l may sometimes be acceptable, but higher is dangerous
Sodium	135–145 mmol/l	Rarely changed
Phosphate	0.8–1.4 mmol/l	Keep around 1.8 mmol/l or less
Calcium	2.1–2.6 mmol/l	Keep as normal as possible
Parathyroid hormone	According to laboratory	Less than 2–3 times normal level
Haemoglobin	130–180 g/l (men) 115–165 g/l (women)	Around 110 g/l to normal with erythropoietin (note that 110 g/l = 11 g/dl)
White blood cells	4–11 x 10^9/l	Keep as normal as possible
Platelets	150–350 x 10^9/l	May be slightly low
Albumin	35–50 g/l	Keep as normal as possible
24-hour urine protein	Less than 300 µg	Sometimes, a huge amount of protein can be found in urine
Creatinine clearance; glomerular filtration rate	About 100 ml/min	Decreases as kidney function falls

Note: Average values fall a little with age

with other tests to estimate kidney function, or to collect urine for 24 hours to measure creatinine clearance. Both tests are described at the end of this article.

Urea tests

Urea is a small molecule produced from protein and excreted by the kidneys, and the level of urea in the blood rises in kidney failure. It is not such an accurate test for kidney function as creatinine tests, but it is useful when used together with creatinine tests, because it is affected by:

- How much protein you eat (it is low if you do not eat enough protein)
- Whether you have taken in enough fluid (it rises if you are dehydrated).

Potassium (K) tests

Potassium comes from food, especially fruit, vegetables and nuts. When you eat more potassium than the body needs, the extra amount is normally put out by the kidneys. Potassium rises in people with kidney failure. High levels of potassium can be very dangerous, as they cause serious heart rhythm abnormalities, including cardiac arrest. Fruits and vegetables often contain a lot of potassium (Figure 2), and some patients with severely damaged kidneys, or those on dialysis, may need to limit the amount of fruit and vegetables they eat. Speak to your dietitian if this affects you.

Potassium levels can rise with some drugs, and this may create extra problems if the kidneys do not work properly. Some things can cause inaccurately high potassium results, for instance delays in getting the blood sample to the lab. Dangerously high potassium levels can be treated by giving sugar (glucose), insulin and other measures. If it is very high and kidney function is very poor, dialysis may also be necessary.

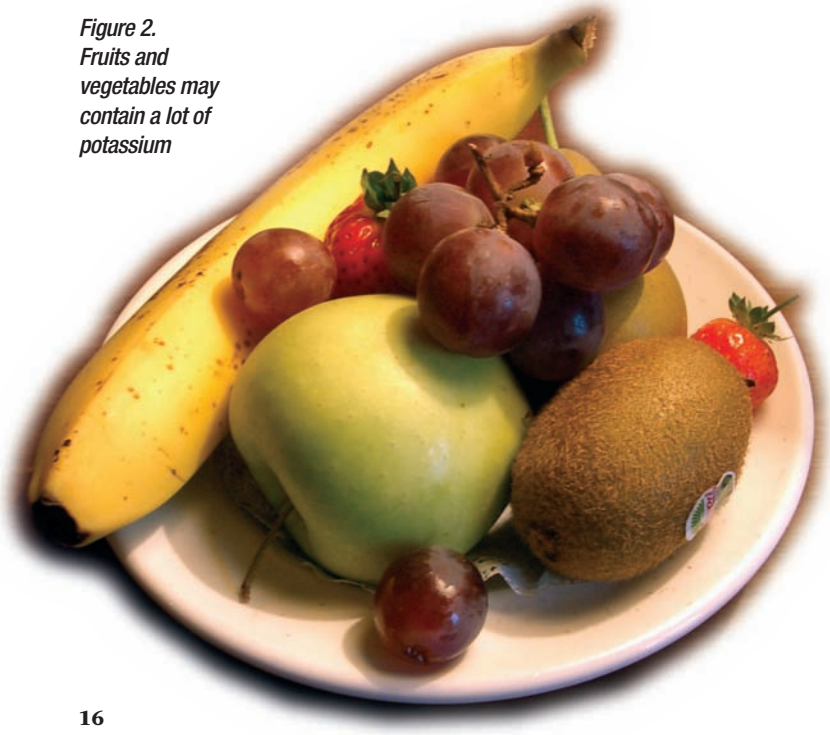

Figure 2. Fruits and vegetables may contain a lot of potassium

Box 1. Calcium and vitamin D in renal failure

Calcium and phosphate form the hardness of bone. Calcium phosphate itself is like stone. Parathyroid hormone (PTH) and vitamin D are important in the formation and maintenance of bone. The vitamin D that you eat is only effective if the kidneys convert it into an active form. In kidney diseases this doesn't happen, so many people need to take artificial forms of vitamin D (alfacalcidol or calcitriol) that is already active. Vitamin D increases the amount of calcium absorbed from food, and is important for normal bone formation – rickets is caused by vitamin D deficiency. PTH is produced by the parathyroid glands, four small glands that lie behind the thyroid gland in the neck. PTH is often over-produced in kidney failure, and the glands may need to be removed to prevent serious bone disease.

Sodium (Na) tests

Sodium comes from salt (sodium chloride). When the kidneys do not work properly, its amount increases in the body, but its blood level does not change much. That is because sodium makes you thirsty, so you drink more until the sodium level becomes normal again. Increased sodium in the body can cause high blood pressure, oedema (swelling), and even fluid on the lungs (pulmonary oedema). Diuretic drugs (such as furosemide or bendroflumethazide) increase the sodium put out in urine. Most people with kidney disease need to keep down the amount of salt in their food, and many need to take diuretics.

What tests are done to measure calcium and test for bone disease?

Bone disease can be a big problem in people who have had kidney disease for a long time. Preventing and treating it can be tricky. Treatment with special kinds of vitamin D is often necessary, but the treatments themselves may cause high calcium levels. The aim of treatment is to:

- Keep calcium levels normal
- Ensure that phosphate levels are not too high
- Ensure that parathyroid hormone (PTH) levels are not too high (see below).

Phosphate (PO_4) tests

Phosphate levels are high in kidney failure, and this may worsen the bone disease, and cause itching and calcium deposits in the body, especially in arteries. Patients are often asked to

limit the amount of phosphate in their diet, and to take tablets called phosphate binders that stop the phosphate that you eat from getting out of your gut and into your blood. Some of these phosphate binders contain calcium, so they can raise blood calcium too.

Calcium (Ca) tests

It is important to check calcium levels regularly in people with kidney diseases. These levels may become low without treatment with special forms of vitamin D (calcitriol or alfacalcidol). However, too much vitamin D, some phosphate binders, and PTH (see below) may cause high calcium levels (Box 1).

Parathyroid hormone (PTH) tests

PTH rises in kidney failure and this leads to loss of calcium from the bones into the blood, causing high blood calcium and thinning of the bones. Sometimes it is difficult to control PTH levels, despite the treatments mentioned above, and the parathyroid glands have to be removed – an operation called parathyroidectomy. The normal level of PTH is different in different labs. Too little PTH may also be harmful, and in kidney failure it is recommended to keep its level less than two to three times the normal level, rather than completely normal.

What other blood tests may I need?

Haemoglobin (Hb) tests

Haemoglobin is the red protein in blood. It fills red blood cells and carries oxygen around the body. The kidneys produce a substance called erythropoietin (EPO), which stimulates the bone marrow to produce red blood cells. Loss of EPO production is the major cause of anaemia in kidney failure. Without treatment, Hb levels could fall to 50% of normal or lower. Treatment with artificial EPO has been a huge advance for patients with kidney failure, as they no longer need to suffer from severe anaemia. Tests for Hb are necessary to get the EPO dose right, and to detect bleeding and other problems.

White blood cell (wbc) tests

White blood cells fight infection in the body. Their level is often raised in the presence of infection, but they may become low with some infections, as well as with some drugs. White blood cells consist of different types, but the most important ones for fighting common infections are called neutrophils.

Platelet (plats) tests

Platelets are important in the formation of blood clots to stop bleeding. Very low platelet counts are associated with risk of serious bleeding. People with kidney failure often have slightly low (but safe) platelet counts. Some drugs used to treat kidney diseases may cause low wbc, plats or Hb.

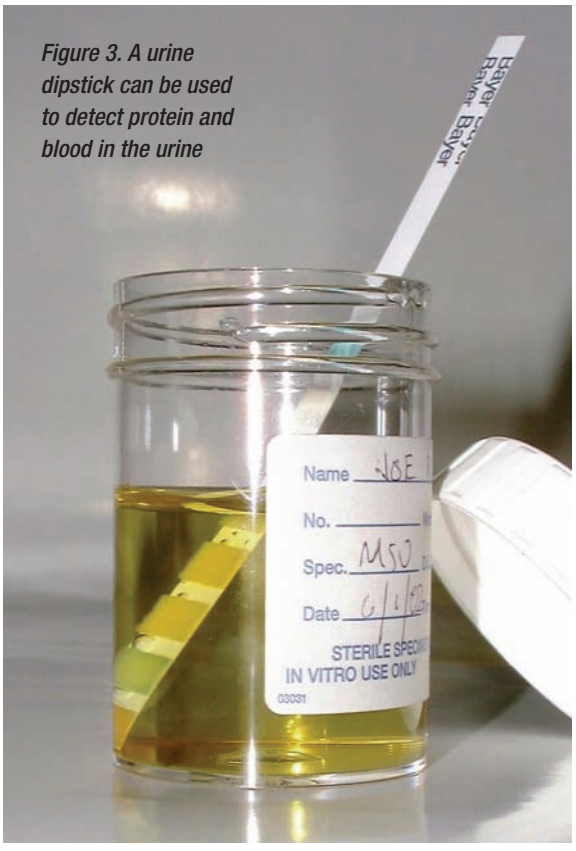

Figure 3. A urine dipstick can be used to detect protein and blood in the urine

Albumin (Alb) tests

Albumin is an important protein in the blood that is made in the liver. It may be low if:

- There is a severe protein leak in the kidney – this is called nephrotic syndrome
- Someone is severely malnourished (not eating enough, usually because of illness) or seriously ill
- There is severe liver disease.

Albumin binds calcium, so calcium levels seem lower when albumin is low.

Urine tests

What are dipstick urine tests for?

This is a very simple test that is commonly done in clinics and surgeries. It is performed by putting a special strip into a fresh urine sample (Figure 3). It can detect protein and blood in urine, which will change the colour of the strip. Some sticks also detect sugar, infection, and so on. Very small amounts of albumin are an early sign of some kidney diseases, but the usual sticks will not detect this – special tests are needed. Otherwise, the sticks are very sensitive.

What is microscopy and culture?

Looking at urine under the microscope can give useful information to help with the diagnosis of some kidney diseases. Many things can be seen; for example, red blood cells, white blood cells,

crystals and bacteria. If there are bacteria or white blood cells, this may suggest urine infection. To confirm this, bacteria are allowed to grow on special plates overnight (culture). To ensure good results, urine for microscopy or culture should be collected 'mid-stream' – that is, not the first or last bit of urine that you pass, which may contain bacteria or cells normally found on the skin.

What other urine tests are there?

In kidney diseases, there is often a leak of protein into the urine (proteinuria). Measuring the amount of protein lost in urine that is collected over 24 hours can show how severe the disease is, and may give a clue as to which part of the kidney is affected. Single urine samples can be used to give nearly as good information, by comparing the amount of protein and creatinine in the same sample (protein/creatinine ratio).

Twenty-four-hour urine collection can also give a more accurate measurement of how well the kidneys are working – the creatinine clearance. The kidneys filter the blood at a rate of 100–125 ml/min; over 150 litres per day, or 35 gallons (Figure 4). This is called glomerular filtration rate (GFR), and it is the best measure of how well the kidneys are working. A creatinine clearance test is not a perfect guide to GFR, but it is very useful and, in early kidney disease, it becomes abnormal before blood tests for creatinine do. It is done by comparing the amount of creatinine in 24-hour urine with the amount in the blood.

Twenty-four-hour urine collection can give a more accurate measurement

Are there other ways of measuring glomerular filtration rate?

There are two other major ways. In one, a tiny amount of a radioactive substance is injected and its rate of travel through the kidney is measured. In the other, simple blood tests (including creatinine) are used, along with age, sex and sometimes weight, to predict GFR. This is not as accurate, but it is much simpler. The 'Modification of Diet in Renal Disease' (MDRD) equation is commonly used for this as it does not require weight – we are likely to be using it increasingly to detect kidney disease in the future.

Figure 4. Normal kidneys filter over 100 ml/min (over 150 litres) of blood per day. This is processed in the renal tubules so that only about one hundredth of that amount (one to two litres) reaches the urine

Key points

- **Creatinine tests are the best routine blood tests for measuring how well your kidneys are working, although creatinine levels may not be very high in early kidney disease.**
- **The glomerular filtration rate (GFR) is the best measure of kidney function and can be tested through 24-hour urine collection.**
- **Estimated GFR (eGFR) can be calculated from blood tests.**

Further information

You can find out more about blood and urine tests from the following websites.

- Lab Tests Online – a website giving detailed descriptions of each blood test, although these are not specifically for patients with kidney disease. www.labtestsonline.org
- Calculate your own GFR using the MDRD equation, or your creatinine clearance using the Cockroft–Gault equation. You need to know the result of your creatinine level and some other tests for the MDRD; you will need your creatinine level plus your weight for the Cockroft–Gault equation. For both, you are hoping to be as near to 100 as possible. See: http://nephron.com/cgi-bin/MDRDSIdefault.cgi or www.edren.org (go to Handbook – GFR estimation – Calculators).
- Normal kidneys and kidney tests – from: www.edren.org ■

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