Back to basics: common renal blood tests

This article is the second in a series looking at the basics of renal nursing—aimed at newcomers or anyone wanting a refresher. Annette Davies looks at common blood tests, outlining the normal range of levels for certain components in the blood and where abnormal levels may indicated disease.

Blood tests are the cornerstone of the assessment of any patient with renal disease of any aetiology both acute and chronic. It is the aim of this article to provide an overview of some of the more common adult blood tests undertaken on patients with renal disorders—outlining normal values and the implications if the result falls outside these established normal values.

Biochemistry

The urea and electrolytes (U&Es) blood test provides the health professional with an indication as to how well a person’s kidneys are functioning. The kidneys regulate electrolytes within the body to maintaining homeostasis. Therefore, when things go wrong with the kidneys, this can be seen in the resulting blood biochemistry. Renal nurses looking after patients with renal disorders need to have knowledge about normal levels of U&Es and the effect abnormal levels will have on their patient’s health status and wellbeing. Abnormal biochemistry will tell nurses that the patient has some form of renal problem but it cannot inform them as to the cause.

Urea

The normal range of blood urea is 3.5–6.5 mmol/litre (20–30 mg/dl) (Edren, 2010). Urea is a very small molecular weight molecule that is produced by the liver as a by-product of protein metabolism and as such is a waste product of metabolism (Montague et al, 2005). Under normal circumstances the kidneys excrete urea via the urine. In patients whose kidneys have reduced function, the blood urea levels will become elevated in the blood. However, it must be remembered that other factors can also influence the level of urea, so urea cannot be considered a reliable guide to kidney function. Other causes of a high urea include:

- Blood loss
- Dehydration
- High protein intake
- Liver disease.

All of which can stop urea being produced normally. Uraemia (elevated blood urea) causes unpleasant symptoms including (Thomas, 2008):

- Nausea,
- Vomiting
- Pruritus
- Neurological problems
- Prolonged bleeding.

Creatinine

Normal blood serum creatinine is 60–120 mmol/litre (0.7–1.4 mg/dl) and is considered the best routine blood test for measuring how well kidneys are working (Edren, 2010). It is a waste product of creatine phosphate found in muscle and is excreted by the kidneys (Thomas, 2008). Creatinine levels remain fairly constant from day to day but will rise steadily and relatively slowly in chronic kidney disease, while in acute kidney injury (AKI) the rise is rapid. The normal-range levels of creatinine are broad because the amount of creatinine generated depends on the muscle bulk of a person. For example, a large muscular person will generate more creatinine than a smaller less muscular person (Edren, 2010). A raised creatinine level, unlike urea, has very little physiological effects on the body.

Potassium

The normal range of blood potassium level is 3.5–5.0 mmol/litre (Edren, 2010). Potassium ions are necessary for the function of all living cells in the body as they play an important role in membrane polarization preventing muscle contraction and in the transmission of nerve impulses through action potentials in muscles. Most potassium
enters our bodies through food, especially in fruit, vegetables and nuts, with the average adult intake of potassium being approximately 60–100 mmol/day (Springhouse, 2010). Potassium levels are normally precisely controlled by the body, with excess potassium being excreted in the urine. However, potassium levels will elevate in the blood in kidney failure as it cannot be excreted. High potassium levels known as hyperkalaemia can be very dangerous as they can cause serious heart arrhythmias as the action potential transmitting the electrical impulse through the cardiac muscle is excited. On an ECG tall T waves, increased PR interval and widened QRS complexes can be seen as a result of hyperkalaemia (Daugirdas et al, 2007).

**Sodium**
Normal blood sodium (also known as salt) levels are 135–145 mmol/litre (Edren, 2010). Most people eat too much salt in their diet but when the kidneys start to fail, sodium levels in the blood do not always change much. This is probably because sodium causes thirst so the person drinks more until the level is normalized (Edren, 2010). Having too much sodium in the body causes high blood pressure and oedema due to fluid shifts within the body.

**Phosphate**
A normal blood phosphate level is 0.9–1.3 mmol/litre (2.5–4.3 mg/dl) (Edren, 2010). Phosphate in common with many minerals enters the body via food. Phosphate together with calcium helps maintain healthy bones. Phosphate, like calcium, is used in the body to ‘power’ muscle and many other chemical reactions. Phosphate has an inverse relationship with calcium when one goes out of balance the other follows (Springhouse, 2010). If the blood phosphate level is high, which is common in chronic kidney disease (CKD), the calcium levels decrease (Springhouse, 2010). Phosphate control is essential for prevention and management of renal bone disease, arterial stiffening and vascular calcification (Dhingra et al, 2007). Phosphate in the diet is generally associated with protein intake, e.g. meat, fish, chicken, eggs, cheese and milk. In patients with CKD stages 3–5 (not on dialysis) the aim is to keep blood phosphate levels between 0.9 and 1.5 mmol/litre and in dialysis patients between 1.1 and 1.7 mmol/litre. This can be done by controlling the intake of phosphate from the diet in conjunction with phosphate binding drugs (Renal Association, 2010).

**Calcium**
Normal blood calcium levels are 2.3–2.5 mmol/litre (8.4–10.4 mg/dl) (Edren, 2010). In patients on haemodialysis the levels should be maintained between 2.1 and 2.5 mmol/litre (Renal Association, 2010). Calcium is found in food products such as:

- Dairy products
- Green vegetables
- Eggs.

Along with being required for the functioning of the muscles and nerves it is also an important component in blood clotting. Low levels of calcium may lead to brittle thinning bones, very low levels lead to muscle weakness, peripheral pins and needles, and other problems (Renal Association, 2010). Vitamin D analogues, i.e. calcitriol and alfacalcidol, are given to patients to prevent renal bone disease and to control calcium levels. Phosphate binders containing calcium are given to patients with renal disease to keep blood phosphate low but they may also raise blood calcium.

**Albumin**
Normal albumin levels are 35–45 g/litre (Edren, 2010). Albumin makes up more than half of the protein in blood (Skinner, 2005). Albumin is essential for maintaining the colloid osmotic pressure, perhaps more accurately known as the oncotic pressure, which is needed for proper distribution of body fluids between intravascular compartments and body tissues. Low levels of blood albumin can contribute to ankle oedema as fluid moves out of the circulation due to loss of oncotic pressure. Unfortunately different labs use different methods to measure albumin resulting in different results for the same samples (Edren, 2010).

**Bicarbonate**
The normal serum range for bicarbonate is 22–36 mmol/litre (Skinner, 2005). Bicarbonate is an ion found in blood that acts as a buffer to maintain the normal levels of acidity (pH) in both blood and other fluids in the body (Montague et al, 2005). The acidity of blood is affected by foods and/or medications.
that are ingested. The aim of acid base balance is to regulate bicarbonate balance ensuring there is a sufficient amount available to buffer acids. Low levels are commonly seen in renal disease resulting in a metabolic acidosis and a low pH.

**Glomerular filtration rate**

GFR describes the flow rate of filtered fluid through the kidney. For the most direct and accurate measurement of GFR, inulin (a polysaccharides produced by plants) is injected into the plasma, as it is neither reabsorbed nor secreted by the kidney after glomerular filtration. The rate of excretion is measured as it is directly proportional to the rate of filtration of water and solutes across the glomerular filter (Edren, 2010).

In clinical practice, however, most GFRs are estimated (eGFRs) and takes into account the blood serum creatinine, age, sex and ethnic background of the person. This is based on The Modification of Diet in Renal Disease (MDRD) formula which, compared with inulin clearance, slightly overestimates the glomerular function. The National Service Framework for Renal (Department of Health (DH), 2005) recommended that all hospital laboratories should measure eGFRs. It is important to note creatinine is used as it is freely filtered by the glomerulus, but also actively secreted by peritubular capillaries in very small amounts so creatinine clearance overestimates actual GFR by 10–20%. However, this margin of error is acceptable considering the ease with which eGFR is measured.

**Full blood count**

A full blood count (FBC) test is commonly requested as it provides information regarding red and white blood cell levels as well as a platelet count

**Haemoglobin**

Normal levels of haemoglobin (Hb) in adult are approximately 11–18 grams/declitre (g/dl) in men and 11.5–16.5 g/dl in women (Skinner, 2005). Hb carries oxygen around the body. It is common for patients with renal disease to be anaemic (have a low Hb).

**Haematocrit**

The haematocrit sometimes called packed cell volume (PCV) or erythrocyte volume fraction (EVF) is the proportion of blood volume that is occupied by red blood cells. It is normally about 48% for men and 38% for women (Skinner, 2005). A low red blood cell count could be the result of a haemorrhage or anaemia. For patients with CKD anaemia is a very common complication. It is likely that the patient with anaemia will require further investigations, e.g. mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and ferritin. These test are used to diagnosis types of anaemia (Thomas, 2008).

**White blood cell count**

Normal levels of white blood cells (WBC) are 4–11 thousand million per litre (Skinner, 2005). WBCs fight infection, a rise can indicate the presence of an infection, but can be lowered by drugs (such as azathioprine and mycophenolate) and also sometimes by infections. The C reactive protein (CRP) (Skinner, 2005) found in the blood rises in response to inflammation.

White cells can be further subdivided into different subtypes. This is called a differential count. The types of cells are neutrophils, lymphocytes, basophils and eosinophils, with Neutrophils being the most important for fighting common infections, and they are particularly likely to be affected by drugs.

**Platelets**

Normal count is approximately 150–350 thousand million per litre (Skinner, 2005). Platelets main function is to form blood clots. If the numbers are less than 50000 million per litre, known as thrombocytopenia, there is a risk of serious bleeding. It is common for patients with kidney disease to have low platelet counts. However, other diseases such as HIV and disseminated intravascular coagulation (DIC), and certain drugs, may also cause low platelet counts.

**Serology**

This refers to tests used to diagnose antibodies in the blood serum. Such antibodies are typically formed in response to an infection against other foreign proteins or a person’s own proteins in the case of autoimmune diseases. There are three commonly requested tests if an autoimmune disease is suspected:

- **Antinuclear Antibody (ANA)**
- **Antineutrophil cytoplasmic antibodies (ANCA)**
- **Anti-glomerular basement membrane (Anti-GBM) assays.**

**Antinuclear antibody (ANA)**

This antinuclear antibody (ANA) test screens for autoimmune disorders. A positive test result suggests the presence of an autoimmune diseases, for example systemic lupus erythematosus (SLE). Test results can be positive in people without any known autoimmune disease (Edren, 2010).

**Antineutrophil cytoplasmic antibodies (ANCA)**

Antineutrophil cytoplasmic antibodies (ANCA) are
found in collagen and are an important test that aids diagnosis in autoimmune diseases (Thomas, 2008). Anti-neutrophil cytoplasmic antibodies stick to molecules found in white blood cells rather than to foreign material (O’Callaghan, 2007). These antibodies are often found in the blood of patients with vasculitis (inflammatory destruction of blood vessels). There are two basic types of ANCA:

- Protoplasmic-staining antineutrophil cytoplasmic antibodies: p-ANCA
- Classical or cytoplasmic antineutrophil cytoplasmic antibodies: c-ANCA

p-ANCA is seen in diseases such as glomerular basement membrane disease, rapidly progressive glomerulonephritis, inflammatory bowel disease, rheumatoid arthritis and drug-induced vasculitis. c-ANCA is seen in up to 85% of patients with Wegener granulomatosis and vasculitis, Henoch-Schönlein purpura and glomerular basement membrane disease.

Anti-glomerular basement membrane antibodies

Anti-glomerular basement membrane (anti-GBM) antibodies are antibodies against the glomerular basement membrane that can lead to kidney damage, particularly Goodpasture’s syndrome. However, the blood tests assays will vary from unit to unit. The anti-GBM test should be done in conjunction with ANCAAs, as the two types of autoantibodies will often occur together (Edren, 2010).

Coagulation tests

Routine tests of blood coagulation are:

- Partial Thromboplastin Time (PTT)
- Activated Partial Thromboplastin Time (APTT)
- International Normalized Ratio (INR).

All of these are measures of the extrinsic pathway of coagulation. Renal practitioners need to be aware of patients clotting status as it is known that an elevated urea affects the clotting cascade, making patients more prone to bleeding (Thomas, 2008). In addition, renal patients are often prescribed anticoagulants.

Partial thromboplastin time

Normal range for partial thromboplastin time (PTT) is considered to be 25–39 seconds (Skinner, 2005). It is a blood test that measures the time it takes for blood to clot. Activated partial thromboplastin time (APTT) normal range is 24–37 seconds (Skinner, 2005). This test, is often requested to assist in the dosing of anticoagulants. International normalized ratio (INR) is the ratio of a prothrombin time to a normal (control) sample. In a person not taking anticoagulants, the INR should be 1.0 (Skinner, 2005), for patients on anticoagulants, the INR is usually maintained between 2.0 and 3.0 (Lab Tests Online, 2010).

Conclusions

Ask any patients with a renal disorder and they are sure to say that they have many blood tests performed regularly. As can be seen from this review, these tests provide vital information regarding both diagnosis and management of both CKD and AKI. This article has concentrated on the most commonly requested blood tests, but there are a multitude of other blood tests that may be requested, often as a consequence of the results obtained from those discussed in this review. To gain a complete picture of the patient’s condition, the renal team will review these blood test results, often in conjunction with urinal and radiological investigations, to help make a diagnosis and establish the most appropriate patient management plan.

References


Key points

- A basic understanding of the biological processes that occur during dialysis is important
- Visualizing what happens inside the dialyser helps nurses to tailor dialysis to the patients’ needs
- Haemodialysis machines are only tools supporting the delivery of care and the patient should remain the central focus of the process at all times