Understanding blood tests

How blood is taken

Where blood samples are taken

- Blood samples are usually taken in your normal doctor’s office (with some exceptions)
- Your nurse, doctor, or phlebotomist should explain the process to you beforehand and answer any questions you have.
- In most cases, blood samples are taken from a vein in the inside of your arm. This is because this vein (the radial vein) is the easiest to find and to draw blood from without causing any damage.
- In some cases, blood may be drawn from other places, either because your radial vein is hard to find/draw blood from, or because the test is aimed at a specific part of your circulatory system.

Preparing for a blood sample

- Before having blood taken, check with your health team whether there are any requirements. Some tests will need you to fast (avoid eating) for a period of time before the blood is taken.
- If you feel sick, dizzy, or have any new symptoms before your samples are taken, make sure you tell the person who is taking the blood samples. This lets them know what to expect and help to keep you safe and comfortable.
- Drink plenty of fluids before and after your appointment. Water or orange juice are recommended. Tea and coffee are less good, since they make you pee.
- Ask any questions you have. You have the right to be told what the process will be, what tests are being done, and why.

How blood samples are taken (1)

When you go for a blood sample, the standard procedure is:

1. The nurse or phlebotomist will check your details – name, date of birth, address, etc. – to make sure that they are labelling the samples correctly and ordering the right tests.

2. They will then explain the process to you, answer any questions you have, and make sure you're happy for them to continue with the procedure.

3. You will be asked to sit down, roll your sleeve up, and rest your arm on a flat surface like a table or armrest.

4. A tourniquet may be put onto your upper arm to help blood to collect in the veins.

5. The nurse or phlebotomist will use a disinfectant pad to sterilise the skin of your inner elbow (or wherever they plan to take the sample from). This may feel quite cold.

How blood samples are taken (2)

6. To find the vein, the nurse or phlebotomist will press their fingers against your skin. They may ask you to open and close your fist a few times to encourage blood flow and make the vein bigger.

7. A small, hollow needle will be inserted into the vein. This may feel like a sting or a sharp pinch.

8. The nurse or phlebotomist will select a sample tube. These are sterile, sealed vacuum containers which have colour-coded caps to help staff recognise samples for different purposes.

9. The tube fits onto the end of the needle. The vacuum will gently pull blood out of the vein and into the tube – all you have to do is wait a few seconds for it to fill.

10. If you are having more than one sample taken, then when the tube is filled, it can be exchanged for a fresh sample tube. The needle stays in place in your vein, and does not need to be reinserted.

How blood samples are taken (3)

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What happens to my blood sample?

- Blood samples are labelled and recorded by the person who took them. They are added to a computer system to make sure they can be tracked.
- The samples will be sent, along with a request form detailing which tests are needed, to the nearest NHS haemotology (blood science) laboratory.
- The laboratory will do the requested tests. They will not do additional tests. Your doctor has to request any additional tests separately.
- Once the tests are complete, the laboratory will safely dispose of the samples.
- The person who ordered the tests (usually the doctor) will receive the results as a report. They may need to take additional samples if they think the results suggest a need for more tests.
- Your information, including the results of the tests, are kept on record but are not shared with anyone besides your health team.

Basic blood tests

An overview of core blood tests

Basic blood tests

These blood tests are done most commonly, and it is likely that you will have at least one of the below tests completed on your blood sample:

- Blood type (**A, B, AB, O**)
- Rhesus type (**+, -**)
- Blood cholesterol
- Blood glucose (“blood sugar”)

Blood type and rhesus group

Your blood type and rhesus group are mostly used when you are either donating or receiving a blood transfusion.

This is because not all blood types are compatible, and if you are given the wrong kind of blood, your body may not accept it.

Type	Can receive:	Can donate to:
A+	A+, A-, O+, O-	A+, AB+
A-	A-, O-	A+, A-, AB+, AB-
B+	B+, B-, O+, O-	B+, AB+
B-	B-, O-	B+, B-, AB+, AB-
AB+	Any blood type	AB+ only
AB-	A-, B-, AB-, O-	AB+, AB-
O+	O+, O-	A+, B+, AB+, O+
O-	O- only	Any blood type

Blood cholesterol level

- Blood cholesterol, as the name suggests, measures how much cholesterol is in your blood.
- Your results may be given in one of two ways:

  mmol/dL – this will usually be a number between **1-7**

  mg/dL – this will usually be a number between **150-250**

- In general, a lower number is better.
- You may be told your total cholesterol, or it may be broken down into types of cholesterol.
- Ideally, your total cholesterol should be less than **5.2mmol/dL (200mg/dL)**

Blood cholesterol types

- **High-density lipoprotein (HDL)** – sometimes called “good cholesterol”. A higher number is better. Ideally, your HDL should be more than 1.55mmol/dL (60mg/dL)
- **Low-density lipoprotein (LDL)** – a “bad” form of cholesterol. In general, a lower LDL result is better.
- **Non-HDL cholesterol** – all forms of “bad” cholesterol. A lower non-HDL result is better.

Ideally, both LDL and non-HDL cholesterol should be less than **3.36mmol/dL (130mg/dL)**

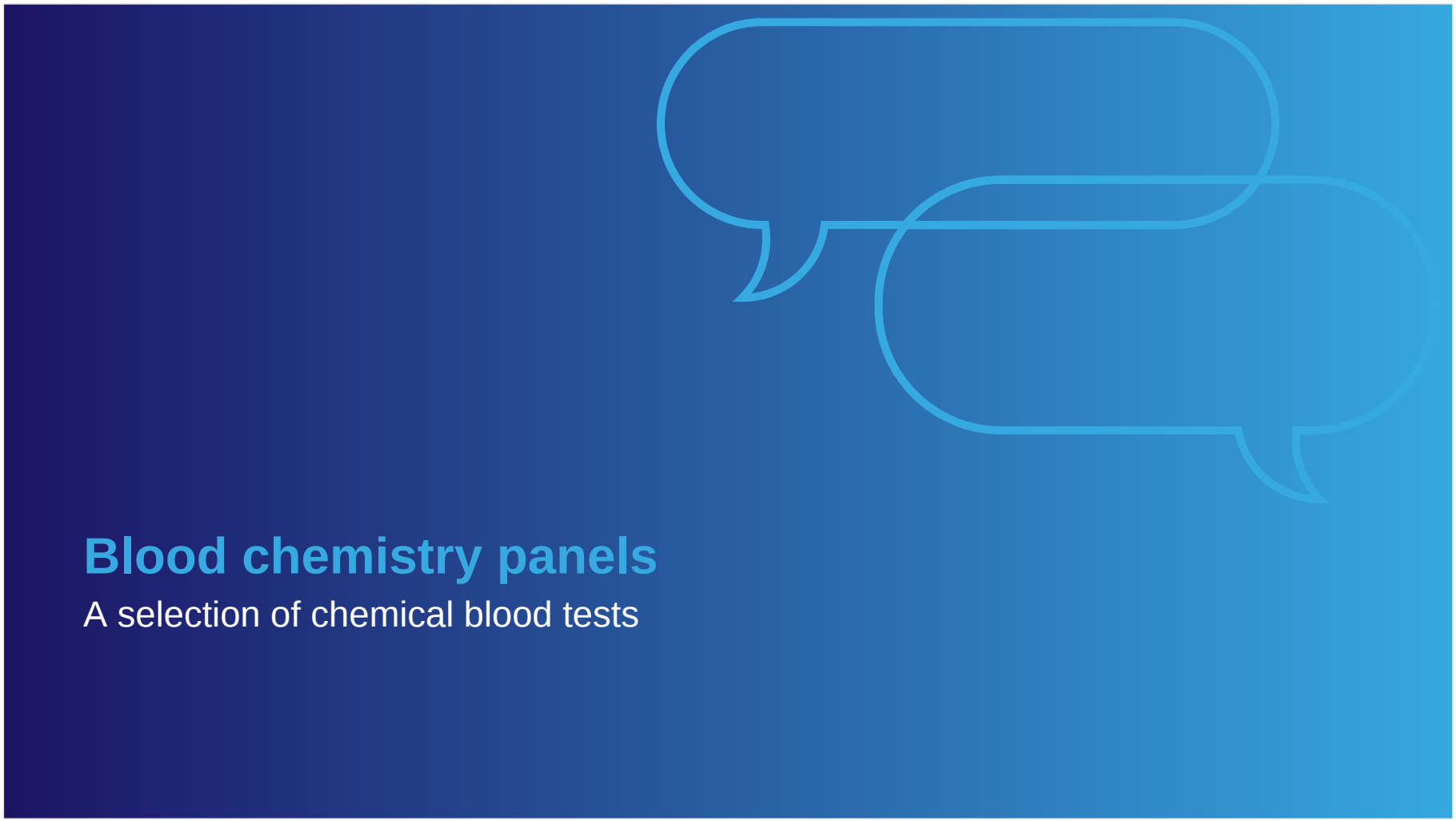
- **Triglycerides** - a fatty substance similar to LDL. A lower triglyceride result is better. Ideally, your triglyceride levels should be less than 1.69mmol/dL (150mg/dL)

Blood gas tests

- Blood gas tests are always done in hospital, because unlike other tests, they need to be tested immediately after the sample is taken.
- Blood for these tests will usually be taken from your wrist.
- This process may be slightly painful.
- If you are using oxygen therapy, you may be asked to turn off your oxygen for 20 to 30 minutes before the test, to measure what the gas levels are like when you are breathing “normal” air.

Blood culture

- Blood cultures are used to test for infections in the blood.
- Your doctor or nurse will take at least two blood samples from different sites on your body. This is usually from veins on your arms.
- You do not need to do anything to prepare for these samples.
- The samples will be taken into special bottles that encourage the growth of bacteria and fungi. The samples will be incubated overnight. They can then be tested to see what bacteria or fungi may be growing in your blood.


Blood chemistry panels
A selection of chemical blood tests

Blood chemistry

A blood chemistry panel (also called a metabolic panel) is a set of tests which measure the levels of various natural chemicals in your blood.

This usually includes five tests:

1. Blood urea nitrogen
2. Creatinine
3. Blood glucose
4. Carbon dioxide (CO2)
5. An electrolytes panel

Blood urea nitrogen (BUN)

Urea is a waste product made by your liver, which passes out through your kidneys as urine. It has a high nitrogen content, which is what a BUN test actually measures.

A high BUN level might suggest:

- Kidney problems
- Dehydration
- Heart failure

However, a high BUN level can also be caused by a high-protein diet.

You may have a low BUN level if you are pregnant, or if you have a problem with your liver.

Ideally, your BUN level should be between **10-20mg/dL (3.6-7.1mmol/L)**

Creatinine

Creatinine is a waste product formed when you convert food into energy. It is passed out of the body through the kidneys in urine. Blood creatinine can be used, on its own or alongside BUN level, to measure your kidney function.

Your creatinine is generally considered high if it is above **1.3mg/dL**

You may see a **BUN:creatinine** ratio on your paperwork. Ideally, this will be between **6-25**.

- **A higher number may be caused by kidney problems or bleeding.**
- **A lower number may be caused by liver problems or low protein intake.**

Blood glucose

Blood glucose ("**blood sugar**") is a measure of how much sugar is carried in your blood. This is important because your cells need sugar to produce energy.

High blood sugar (**hyperglycaemia**) or low blood sugar (**hypoglycaemia**) can cause problems.

Blood glucose is written in **mmol/L.**

	Healthy range
Non-diabetic (before meals)	**4.0-5.9 mmol/L**
Non-diabetic (after meals)	Less than **7.8 mmol/L**
Diabetic (before meals)	**4.0-7.0 mmol/L**
Diabetic (after meals)	Less than **9.0 mmol/L**

HbA1c

HbA1c refers to something called **glycated haemoglobin**.

This can show where your blood glucose level is now, but also if you have had high blood glucose at any time in the last 8-12 weeks.

This test is usually used to help diagnose or monitor diabetes.

Your HbA1c level is expressed in **mmol/mol** or as a **percentage of total haemoglobin**.

HbA1c	mmol/mol	%
Normal	Below 42 mmol/mol	Below 6.0%
Prediabetes	42 to 47 mmol/mol	6.0% to 6.4%
Diabetes	48 mmol/mol or over	6.5% or over

Electrolyte blood panels

Electrolyte panel

Electrolytes are chemicals that conduct electrical impulses in your body. This is important for a lot of things, including your nervous system. Measuring electrolytes can also help to show your blood's pH, and how much water is in the blood.

An electrolyte panel typically measures four chemicals in your blood serum (the liquid part of your blood):

1. **Chloride** (Cl)
2. **Potassium** (K)
3. **Sodium** (Na)
4. **Bicarbonate** (HCO3)

Your electrolyte panel may also include a measure called the **anion gap**, which can highlight general problems with your electrolytes.

Serum chloride (Cl)

Chloride is a key electrolyte in the body. It usually increases or decreases in proportion to sodium (Na) since the two easily combine to make salt (NaCl). However, sometimes chloride may be out of proportion to sodium when your blood is too acidic or too alkaline.

- High chloride levels can be caused by dehydration, or by certain breathing problems.
- Low chloride levels can be caused by chronic lung disease like emphysema, or by vomiting or diarrhoea over a long time.

Your chloride value should usually be between 95–108 mmol/L

Serum sodium (Na)

Sodium is a key electrolyte in the body. It usually increases or decreases in proportion to chloride (Cl) since the two easily combine to make salt (NaCl).

High sodium levels are usually caused by dehydration.

Low chloride levels can be caused by several things:

- Losing salt through vomiting, diarrhoea, or sweating
- Too much water in the body, which can indicate kidney or heart problems
- Taking diuretics, which you may have been given to lower your blood pressure

Your sodium level should usually be between **133–146 mmol/L**

Serum potassium (K)

Most of the potassium in your body is actually in your cells, and the amount in your blood is very tightly controlled.

Abnormal blood potassium levels can affect nerves and muscles throughout the body. This may cause heart problems and other issues.

High serum potassium is connected to kidney disease and diabetes. It can also be caused by certain medications, such as ACE inhibitors or painkillers like ibuprofen.

Low serum potassium is caused by losing potassium through vomiting, diarrhoea, or urine. It is often associated with taking diuretics.

Your serum potassium should usually be between **3.5–5.3 mmol/L**

Serum bicarbonate (HCO

Bicarbonate is a form of carbon dioxide which is stored in the blood. The level of bicarbonate can give your doctor an idea of how acidic or alkaline your blood is.

Where your bicarbonate levels are abnormal, it usually means that your blood is having trouble maintaining its pH.

Low bicarbonate can be caused by: kidney disease, chronic diarrhoea, metabolic problems, or hormonal problems.

High bicarbonate can be caused by: respiratory problems like COPD and other lung diseases, severe vomiting, or metabolic problems.

Your bicarbonate level should usually be between **22–29 mmol/L**

Anion gap (AG)

The anion gap is a calculated number which compares the number of positively-charged electrolytes (cations) against the number of negatively-charged electrolytes (anions).

Usually, this is calculated using the formula:

Sodium - (Chloride + bicarbonate) = Anion gap

If the anion gap is higher than expected, there are more anions in the blood than expected. You may need further tests to discover what is in the blood to cause this imbalance.

Because different labs use different formulae to calculate the anion gap, the normal range may vary depending on which laboratory did the test.

Blood count

Blood count

A blood count shows the levels of different types of blood cells in your body. This includes:

- White blood cell (WBC) count
- Red blood cell (RBC) count
- Haemoglobin
- Platelet count
- Haematocrit

White blood cell (WBC) count

White blood cells are a key part of your immune system. They fight disease and infection.

High WBC levels may mean you have an infection, inflammation (swelling), or autoimmune condition.

Low WBC levels may be associated with some medications, severe infections, or damage to the liver or bone marrow.

The usual ideal range is between **4.0-11.0 x109/L**

Types of white blood cell

There are 5 main types of white blood cells which may show up in your blood count. These are:

- **Neutrophils** (%Neutrophil, also called Band or ANC)
- **Lymphocytes** (Lymphs)
- **Monocytes** (%Mono)
- **Eosinophils** (%Eos)
- **Basophils** (%Bas)

There are no simple reference values for these. Your doctor will be able to explain what the percentages of these WBC types mean.

Red blood cell (RBC) count

Red blood cells carry oxygen, carbon dioxide, and nutrients in your blood.

Low RBC count may be associated with anaemia or severe blood loss.

High RBC count may be associated with dehydration, but can also be a result of too many blood counts being done in a short space of time.

	Minimum	Maximum
Men	4.7 million/McL	6.1 million/McL
Women	4.2 million/McL	5.4 million/McL

Haemoglobin (Hb)

Haemoglobin is the chemical in your red blood cells which carries oxygen and carbon dioxide.

Usually, your haemoglobin levels will be closely linked to your red blood cell count.

This means that a high haemoglobin level usually goes along with a high RBC, and vice versa.

	Minimum	Maximum
Men	13.5 g/dL	17.5 g/dL
Women	12.0 g/dL	16.0 g/dL

Platelet count

Platelets are small fragments of cells which play a key role in your blood clotting.

The number on your test results will be shown as a **total number per litre of blood**. This will be labelled as either Platelet count or Thrombocyte count.

Low platelet counts may be associated with: medication use, immune problems, vitamin B deficiency, infection, liver disease, bone marrow disorders, cancers of white blood cells, chemotherapy or radiotherapy.

High platelet counts may be associated with: infection, inflammation, recent injury or bleeding, some drugs, some forms of anaemia, or spleen damage.

The standard range is **150 to 450 x109/L**

Haematocrit (Hct)/Packed cell volume (PCV)

Haematocrit – also known as "**packed cell volume**" or **PCV** – measures the total volume of cells in your blood.

It will be shown as a percentage of the total volume of your blood.

This is mostly related to your red blood cell count, since most of the cells in your blood are red.

Haematocrit is most often used to judge things like anaemia (which will cause a low value) or dehydration (which will cause a high value)

	Minimum	Maximum
Men	41%	53%
Women	36%	46%

Blood coagulation tests

Coagulation tests

Coagulation is the ability of your blood to clot.

You may be given a coagulation panel if you are undergoing surgery, if you are taking blood thinners such as warfarin, or to see if you are at high risk of a blood clot.

These tests measure three things:

- **Prothrombin (PT) time**
- **International normalisation ratio (INR)**
- **Partial thromboplastin time (PTT)**

Prothrombin time (PT)

Prothrombin time is the time it takes for your blood to form a clot.

Your prothrombin time may be longer if you are taking anticoagulants (“blood thinners”).

If you are not taking anticoagulants and still have a long prothrombin time, you may need additional tests to find the cause.

The healthy range for prothrombin time will depend on which laboratory runs the test and what method they use, but it is generally around **12-13 seconds**.

International normalisation ratio (INR)

The international normalisation ratio (INR) is a more specific version of the **prothrombin time.** INR specifically measures the activity of warfarin and vitamin K in clotting your blood.

INR will usually be used to monitor how well anticoagulant medication is working.

For most people, the target INR is between **2.0 and 3.0**. However, if you are at a high risk of clots, this may rise to **3.0 to 4.0.**

A higher INR means that you are **less likely** for your blood to clot, but **more likely** to bleed too much when cut or injured.

Partial thromboplastin time (PTT)

PTT, also called **aPTT** (Activated Partial Thromboplastin Time) or **KCCT** (Kaolin Cephalin Clotting Time), is another measure of how long your blood takes to form clots.

Your blood clotting is controlled by a range of coagulation factors (which are given numbers in Roman numerals, such as Factor I or Factor VII). Your PTT will show if any of these are low or missing.

The PTT workup is extremely complicated and will vary depending on the laboratory which performs the tests and the doctor who requests them. Your doctor will explain the results if asked.

Comparing PT and PTT

Sometimes, if you have a problem with your blood clotting, your prothrombin and partial thromboplastin times will be compared to help find the cause.

These results can suggest causes for your symptoms.(see table)

PT RESULT	PTT RESULT	POSSIBLE CONDITIONS:
High	Normal	Liver disease Low vitamin K Low/damaged factor VII
Normal	High	Low/damaged factor VIII, IX, XI or XII von Willebrand disease Lupus anticoagulant
High	High	Low/damaged factor I, II, V or X Liver disease Disseminated intravascular coagulation (DIC)
Normal	Normal	Low platelet function Thrombocytopenia (low platelet count) Low factor XIII Weak collagen

Arterial blood gas tests

Arterial blood gas tests

Arterial blood gas tests measure what gases are being carried in your blood, and are useful to see how effectively your respiration (breathing) is working. The results are often difficult to interpret, but you can ask a doctor or nurse to explain them to you.

There are five standard blood gas tests:

- **pH**
- **pCO2**
- **pO2**
- **HCO3**
- **O2 saturation**

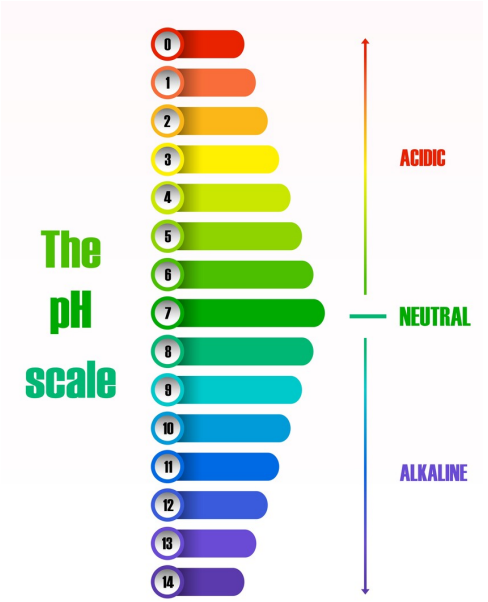
Blood pH

You may be familiar with the idea of pH – the main way to measure acidity.

pH is a scale from 0 to 14:

- 0 is the most acidic possible
- 14 is the most alkaline/basic possible
- 7 is neutral

Your blood pH should be **7.35 - 7.45**



PO2 and PCO2

PO2/CO2 stands for the **partial pressure** of oxygen and carbon dioxide respectively – the amount circulating in your blood. This is shown in **mm Hg** (millimetres of mercury, a unit of pressure).

PO2 and PCO2 are directly linked. Where one is low, the other will be high.

A **high PO2** and **low PCO2** means you will have a higher blood pH (your blood becomes more alkaline, called **metabolic alkalosis**)

A **low PO2** and **high PCO2** means you will have a lower blood pH (your blood becomes more acidic, which is called **metabolic acidosis**)

Healthy PO2 is usually between **83-108 mm Hg**

Healthy PCO2 is usually between **35-45 mm Hg**

Blood bicarbonate (HCO3)

HCO3-, or bicarbonate, is a waste product which is produced when your cells make energy. It is also the form in which most of the carbon dioxide in your blood is carried.

Bicarbonate is also produced and absorbed by the kidneys to control blood pH.

A **high bicarbonate level** usually means your blood pH will be higher (more **alkaline**)

A **low bicarbonate level** usually means your blood pH will be lower (more **acid**)

HCO3 should usually be between **21.00 to 28.00 mEq/L**

Oxygen saturation

Oxygen (O2) saturation is a measure of how much of the oxygen in your blood is bound to the red blood cells.

Only O2 bound to the red blood cells is available to be used by your body.

This is shown as a **percentage of total oxygen content** in your blood.

If you have low oxygen saturation level, your cells may have trouble accessing energy even if you have a high PO2.

Healthy oxygen saturation levels are usually around **95-100%**.

Inflammatory markers

Blood tests for inflammation

Inflammation tests

If your doctor suspects your problem may be caused by inflammation (swelling), they may ask for special tests to measure inflammation in your body.

Inflammation can be caused by an infection, an injury, or certain autoimmune conditions.

The most common tests for inflammation are:

- **C-reactive protein** (CRP) test
- **Erythrocyte sedimentation rate** (ESR) test
- **Plasma viscosity** tests

C-reactive protein (CRP)

C-reactive protein is a protein made by the liver. It is released into the blood within a few hours of an injury, infection, or other inflammation.

A CRP level higher than **10 mg/L** suggests you have a clinically important amount of inflammation.

This can be a result of:

- infection or injury
- heart attack
- recent surgery
- a flare-up of chronic inflammatory disease

Erythrocyte sedimentation rate (ESR)

Erythrocyte (another word for red blood cell) sedimentation rate measures the speed at which red blood cells separate from the plasma (the liquid part of the blood) in a tall, thin tube of blood.

Normally, the cells fall slowly. This gives you a **low ESR**.

High ESR is associated with inflammation, but can also be caused by anaemia, kidney failure, or pregnancy.

ESR on its own is not enough to make a diagnosis.

	Younger than 50	50 or over
Men	<15 mm/hr	<20 mm/hr
Women	<20 mm/hr	<30 mm/hr

Plasma viscosity (PV)

Plasma is the liquid part of your blood. Plasma viscosity tests how viscous (“sticky”) the plasma is. It is displayed in **mPas** (milli-Pascals) which represent the amount of pressure required to push the plasma through a small tube.

Your plasma tends to become more viscous in response to inflammation.

High PV may be associated with infection, inflammation, or certain forms of cancer (myeloma or lymphoma). The cause of a high PV is usually clear – PV is rarely used to diagnose anything on its own.

Under normal circumstances, PV is usually around **1.3-1.7 mPas**

Further information and support

Comments and feedback

If you have any comments or feedback about the contents of these slides, please contact CHSS directly:

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