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Bring Your Blood Results to Life

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Have you ever wondered what the normal blood results are for our patients? Actually, the term "normal" is rather subjective. Variations in what are referred to as "normal values" can be expected because each veterinary diagnostic lab and "in clinic" laboratory equipment will have its own "normal values" or “reference ranges” calibrated to specific standards.

An essential tool in the health care of our patients is the blood panel. Most clinics have procedures for assessing blood values for patients either on site or via a nearby veterinary diagnostic laboratory, which is a crucial component of a full evaluation. The utilisation of data obtained from a complete blood count (CBC) & blood chemistry panel has become common practise thanks to newer instruments and methods for examining blood.

Numerous different cellular & metabolic markers can be assessed, and when combined with additional diagnostic tools like a urine analysis, faecal testing, radiographs (X-rays), a physical examination, and patient history, a precise picture of a patient's health status can be guaranteed.

Nowadays we talk about a “minimum database” of what should be assessed when doing diagnostic testing. This includes:

1. CBC
2. Biochemistry
3. Urinalysis

You can choose to add of additional tests depending on the clinical signs of the presenting patient.

Like medicine in general, veterinary medicine is both a science and an art. Any vet who only considers scientific evidence while ignoring the art would be misled. It takes reflection, experience, and a careful analysis of the patient's physical and emotional characteristics to interpret scientific data accurately. The doctor won't be able to make a decision until the two are combined—the scientific, impersonal, facts and the "hands-on" assessment of the entire patient.

Today's veterinary patients have a clear advantage over their ancestors from just a few decades ago. There were only a few simple blood tests available to veterinarians at the time and were usually only offered at external veterinary laboratories.

Nowadays, most veterinary hospitals have "in-house" blood analysers that can give a lot of information quickly. Some rural & remote clinics still rely on veterinary labs to collect blood samples and return the results. A few years ago, this level of veterinary practise was merely a pipe dream; today, routine blood testing is the daily norm at all clinics.

The art of veterinary medicine is then used once the clinician has the scientific data. "Treat the patient, not the paper," is a phrase doctors are taught. Does having a blood result that appears to be greater than normal, for an analyte indicative of renal function, such as creatinine, always mean that the kidneys are damaged?

What if the sodium level seems a little too high? Does that indicate that the kidneys aren't working properly or that there is a hormonal imbalance? Or is the patient merely dehydrated from lack of water during the last 12 hours?

Even before the final diagnosis is fully apparent, the practitioner must mentally picture the entire canvas of possibilities in order to practise good veterinary medicine. A urine sample must also be assessed because there are so many factors that might impact blood chemistry; otherwise, the accuracy of data that show abnormality may be in doubt. This requirement is supported by many veterinarians.

It is interesting to note that, statistically, one in twenty test results could be abnormal without actually being relevant. In other words, a dog can, for instance, have a liver enzyme score that is consistently higher than normal and nevertheless be in good health.

Only the veterinarian can determine the medical relevance of an abnormal test result by taking into account the patient, patient history, and degree of value change. Additionally, if a test result is deemed important, it might prompt further examinations to confirm the importance of a problem for the animal or to learn more about the issue at hand.

Keeping your patient healthy throughout his or her life relies upon preventive care, careful observation, communication, and maintaining consistent veterinary care.

This brings us to the point of establishing a ***"baseline"*** for every patient

When our pet is young and for a good portion of their adult life, we might only see the energetic, happy, and healthy companion that we have grown to know and love. We might not think of the significance of monitoring our pet at this time of life for their long-term health. But it's precisely when your pet is young that we can set a baseline for health and determine what is typical for your particular pet.

This is why having a blood test as a non-optional part of a preanaesthetic profile at the time of desexing is important. By having this test, we can easily see what is "normal" for a patient at a young age (approx. 6-8mths). Then by doing wellness checks yearly, or every second year, and including a full blood panel, including urinalysis, can establish the baseline for your pet.

Prior to the development of disease, it is useful to determine a baseline for each individual patient. Reference ranges provide a wide variation in normal and determining an individual patients' baseline allows for the trending of values over time.

Our ability to carefully assess and respond to health concerns before they have a greater impact, or in some circumstances, prevent their formation, depends on enhancing our level of awareness of our pets' health, including even the subtler subtleties of changes in appetite, behaviour, and energy.

Some of the additional benefits of maintaining a baseline of your pet's health include:

- Disease and illness prevention
- Early detection and increased treatment efficacy
- Pain prevention through early detection
- Greater chances of longer life expectancy
- Monitoring for age-related issues and intervening in degenerative conditions earlier
- Reducing the likelihood of more serious and costly health conditions

Some diseases are identified based on a rise over previous levels rather than an elevation above the usual reference range. It is possible to promote healthy longevity and enable earlier diagnosis and therapeutic intervention by detecting latent disease at all stages of life.

A disorder where early intervention may stop or delay disease progression is chronic hepatitis, which affects some breeds in their young adult life stage. Knowing a breed's propensity for a disease will help determine the right tests to do when a patient is in each stage of life. For certain breeds, older patients, patients with diagnosed disease processes, testing might be done more frequently. Think about combining the tests with the advised routine minimal database prior to anaesthesia or surgery

Avoiding Errors

Veterinary clinics must consider implementing quality assurance, quality control, and standard operating procedures as steps toward ensuring you are getting reliable results every time.

A quality assurance (QA) programme that establishes the planning, implementation, education, monitoring, and assessment parameters for the entire process—from preanalytical through analysis to postanalytical—is required to assure trustworthy results. Standard operating procedures (SOPs) and protocol development are common ways to do this.

Standardization of methods is required to reduce the impact of individual variability on the validity of results. Written SOPs serve as a framework for coordination and management of the entire procedure. SOPs must be accepted by all veterinary team members in order to be effective. All team members must initially and thereafter receive education, updates, observation, and evaluation in the use of the SOPs in order to reduce drift. The SOPs must include the who, what, when, where, and why of each step in the process in addition to the how. SOPs must be evaluated on a regular basis, and changes should only be made when absolutely necessary.

These SOPs need to include things such as:

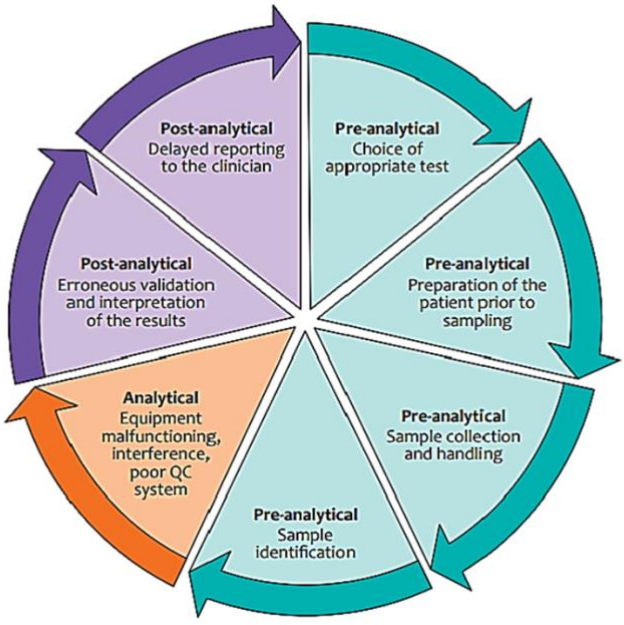
- Sample collection
- Sample handling and preparation
- Running of samples
- Transportation & storage

Common Reasons for Unexpected Results

- "Snapshot-in-time" phenomenon: results are representative of the patient at the time of collection, but have been skewed by an influencing factor (e.g., excitement, sedation) with a very short-term effect
- Lack of characteristic signs of a medical condition
- Presence of disease that is new to the geographic area
- Individual physical, physiologic, and/or psychologic factors that are not characteristic
- The patient's species, breed, or life stage
- Insufficient patient history
- Lack of order for and/or performance of a relevant test
- Test methodologies that lack specificity and/or sensitivity
- Differences in reporting methods
- Human factors
- Environmental influences
- Expectation that all values within the reference interval for the patient's reference group are "normal" and those that are outside are "abnormal," or vice versa
- Patient or sample mix-up
- Unknown, forgotten, or perceived "unimportant" details

High-tech, new and improved, and quick and easy, are not synonymous with reliability. Nor can technology use suboptimal samples to achieve reliable results.

Most errors will occur in the preanalytical phase, rarely is it an analyser problem or post-analytical error



The Complete Blood Count

What is a complete blood count (CBC) test?

The complete blood count measures the number of cells of different types circulating in the bloodstream. There are three major types of blood cells in circulation – red blood cells (RBC), white blood cells (WBC), and platelets.

Red Blood Cells

Red blood cells, which are produced in bone marrow, pick up oxygen brought into the body by the lungs and distribute it to cells throughout the body. Red blood cells live in the bloodstream for about 100 days and are removed from the bloodstream by the spleen and liver.

Red blood cell numbers can be decreased (anaemia) if they are not produced in adequate numbers by the bone marrow, if their life span is shortened (a condition called haemolysis), or if they are lost due to bleeding. Numbers can be increased (polycythaemia), usually due to concentration of the blood due to dehydration.

A complete blood count also includes a measure of haemoglobin, which is the actual substance in the red blood cell that carries oxygen.

White Blood Cells

There are several types of white blood cells in blood, including neutrophils, lymphocytes, monocytes, eosinophils, and basophils.

Most white blood cells in circulation are neutrophils, which help fight infections.

Lymphocytes also help fight infection and produce antibodies against infectious agents.

Monocytes may be increased in pets with chronic infections.

Eosinophils and basophils are increased in pets with allergic diseases, or parasitic infections.

Platelets

Platelets are produced in the bone marrow and are involved in the process of making a blood clot.

Low platelet counts occur if the bone marrow is damaged and doesn't produce them, or if the platelets are destroyed faster than normal.

The two primary causes of platelet destruction are immune-mediated destruction and disseminated intravascular coagulation (DIC).

Immune-mediated thrombocytopenia happens when the animal's immune system destroys platelets.

DIC is a complex problem in which blood clots form in the body using the platelets faster than the bone marrow can produce new ones. Animals with a low platelet count bruise easily and may have blood in their urine or stool.

The Blood Film

The qualitative evaluation of the blood, also known as a blood smear or blood film evaluation, is the other component of a complete haematological evaluation. Blood smears are made using the EDTA-anticoagulated blood and stained using water-based Romanowsky-type stains (i.e. Diff Quick). The stained blood smear is then examined for estimated counts and morphological characteristics of the blood cells.

Why perform a blood smear evaluation?

An important diagnostic step for confirming the outcomes of an automated analyser, such as a total and differential white blood cell count and platelet count, is the microscopic inspection of a well-prepared blood film. Additionally, it is utilised to recognise extremely crucial diagnostic data that automated analysers are unable to assess, such as changes in cellular morphology that are crucial for diagnosis, the presence of atypical cells, or cellular inclusions. Even in patients who have quantitatively normal findings for all hematologic markers, these morphologic abnormalities and cellular inclusions may still be present.

Every time a CBC is completed, it is good veterinary medicine to review a blood film.

A blood smear analysis should be done routinely with every CBC and is a supplement to both point-of-care and reference laboratory automated haematological counts. For sick animals and those with hematologic disorders, it is particularly crucial. A blood smear enables the veterinarian to verify outcomes, guarantee product quality, and may offer extra information to help with diagnosis and treatment. Through the verification of RBC, WBC, and platelet counts, it offers the capability to validate automated CBC results. It can also help in determine the degree of platelet clumping or the presence/absence of neutrophils. A blood smear analysis also assesses cell shape, which is not provided by automated CBC analysers.

Ideally, a blood smear evaluation should always be performed as part of every CBC, but it is vital in the following clinical situations:

- anaemia (low red blood cell count)
- thrombocytopenia (low platelet count)
- neutrophilia or neutropenia (verify count and examine cells)
- lymphocytosis
- severe illness
- suspicion of haemoparasites
- when certain warning flags are present on the automated CBC report.

Biochemistry

These common blood serum tests evaluate organ function, electrolyte status, hormone levels and more. They are important in evaluating older pets, pets with vomiting, diarrhoea or toxin exposure, pets receiving long-term medications and health before anaesthesia.

The Liver

Liver disease includes any process resulting in hepatocellular injury, cholestasis (impaired bile flow) and both hepatocellular injury and cholestasis together

Categories of Tests for Liver Disease

- Enzymes for detection of hepatocyte injury
- Enzymes for detection of cholestasis
- Tests for evaluation of liver function

Alanine Transferase (ALT)
An enzyme that is mainly found in the liver, with small amounts in the muscles

- Can be an indicator of hepatocyte injury or death

Aspartate Aminotransferase (AST)
An enzyme that is present in high levels in the muscle and liver

- Can be an indicator of injury or death of hepatocyte or muscle cells

Alkaline Phosphatase (ALP)
Enzyme present in many tissues, with a majority found in the liver

- Can be an indicator of cholestasis, drug induction (dogs), increased osteoblastic activity in young animals or due to a variety of chronic diseases

Gamma-glutamyl transferase (GGT)

Enzyme mainly found in the liver

- Can be an indicator of cholestasis, biliary hyperplasia, or drug induction (dogs)

Total Bilirubin (TBIL)

Majority produced from degradation of haemoglobin during normal red blood cell destruction (aging) or due to haemolytic processes

- Two main forms: unconjugated bilirubin (bound to albumin) and conjugated bilirubin
- Used as a measure of liver function, indicator of bile obstruction, and/or as evidence of haemolytic anaemia

Bile Acids (BA)

- Group of steroids produced by hepatocytes from cholesterol
- Function to emulsify fat in intestines and facilitate nutrient absorption
- Used mainly as a measure of liver function, but also for abnormal portal blood flow and cholestasis

The Kidney

Nephrons are the functional unit of the kidneys

- Glomerulus responsible for blood filtration
- Glomerular filtration rate is the best predictor of renal function
- Azotaemia
  - Pre-renal, Renal or Post-renal
  - Requires chemistry & urinalysis (USG) to differentiate

Elevations Due to Pre-renal, Renal or Post-renal Azotaemia

Creatinine (CRE)

- An amino acid produced as the result of normal muscle metabolism and excreted primarily by the kidneys
- Used to indirectly measure glomerular filtration rate (GFR)

Blood Urea Nitrogen (BUN)

- Urea is a waste product formed from normal breakdown of proteins
- Produced in the liver & excreted by the kidneys, colon, saliva and sweat

Uric Acid (UA)

End product of nitrogen metabolism in avian and reptilian species

- Used as an indicator of renal function

Symmetric Dimethylarginine (SDMA)

An amino acid produced by all nucleated cells which is excreted primarily by the kidneys

- Used to indirectly measure glomerular filtration rate (GFR)

Pancreatic Function

Amylase (AMY)

- Enzyme that is produced by the pancreas, intestine, reproductive organs, and salivary gland (pigs)
- Calcium dependent enzyme that functions to break down complex carbohydrates
- Utility for the diagnosis of pancreatitis is limited in dogs, neither sensitive nor specific

Lipase (LIP)

Enzyme that is produced by the pancreas, gastrointestinal and hepatic tissues

- Functions to break down triglycerides
- Used as a screening test for detection of pancreatitis in dogs, neither sensitive nor specific

Energy Metabolism: Carbohydrates

Glucose (GLU)

Energy source for mammalian cells, derived from ingestion of carbohydrates, breakdown of glycogen in the liver, production in the liver, or production in the kidneys (smaller amounts)

Fructosamine (FRUC)

- Formed when glucose is linked to albumin or other proteins in the blood
- Indicator of blood glucose concentrations during the previous 2-3 weeks

Energy Metabolism: Lipids

Cholesterol (CHOL)

Steroid derived from diet or produced mainly in the liver (small amounts produced in other tissues)

- Indication of hepatic function, gastrointestinal disease, and metabolic disorders such as hypothyroidism

Triglycerides (TRIG or TG)

Major dietary fat, also synthesized in the intestinal, liver and adipose tissue, among others

- Concentrated store of metabolic energy

Protein Metabolism

Total protein (TP)
Total blood protein level consisting of albumin and globulin levels

Albumin (ALB)

Protein produced in the liver

- Contributes to oncotic pressure of plasma within vasculature
- Carrier protein that transports bile acids, bilirubin, calcium, and other molecules

Globulins (GLOB)

- Includes hundreds of proteins produced by the liver (majority) or lymphoid tissue (immunoglobulins)
- Obtained via a calculation in general chemistry panels (GLOB= TP-ALB)

Electrolytes

Sodium (Na2+)

- Extracellular electrolyte important for osmolality and extracellular fluid volume
- Also assists with muscle and nerve interaction
- Helps maintain acid-base balance

Chloride (Cl-)

- Extracellular electrolyte that helps maintain osmotic pressure
- Necessary for hydrochloric acid production in the stomach
- Helps maintain acid-base balance

Potassium (K)
Intracellular electrolyte found mainly in muscle cells and bone

- Plays important role in resting membrane potential of cells
- Helps control osmolality of the intracellular fluid

Magnesium (Mg)
Intracellular electrolyte that is important in enzymatic reactions, protein synthesis and neuromuscular contractions

- Found mainly in the bone, skeletal muscle, and soft tissue

Total Calcium (Ca)

- 99% found in the bones and teeth, the remainder mainly in blood and soft tissues
- In blood, it consists of free ionized calcium, protein bound and complexed calcium
- Mineral involved with structural stability of bones and teeth, muscle and nerve function, enzyme activity, hormone release and blood coagulation

Phosphorous (PHOS)

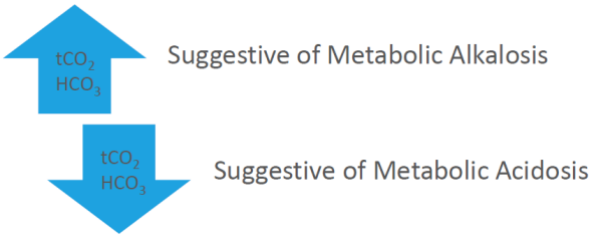
Stored primarily in the bones with smaller amounts in muscle and extracellular fluid

- Mineral that has many roles including structural stability of bones, carbohydrate and energy metabolism and supporting oxygen delivery to tissues
- Primarily excreted in urine

Acid-Base Status

Total Carbon Dioxide (tCO2)

- An estimate of serum bicarbonate (HCO3-)
- Interpreted with electrolytes, it is a useful screening test for the presence of acid-base disturbances



Muscle Injury

Creatine Kinase (CK)

Enzyme found mainly in skeletal, cardiac and smooth muscle as well as the brain

- Used as an indicator of muscle injury
- Aspartate Aminotransferase (AST)
- An enzyme that is present in high levels in the muscle and liver
- Can be an indicator of injury or death of hepatocyte or muscle cells

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UNDERSTANDING YOUR PET'S BLOOD TEST RESULTS

Chemistry tests

Chemistry blood tests assess the fluid component of the blood, providing useful indicators of the health and function of your pet's organ systems and fluid balance. Chemistry tests may include the following:

Alanine Aminotransferase (ALT)
An enzyme released by the liver when the liver is damaged. Elevations may be a sign of liver damage or disease. 🔵

Albumin (ALB)
A protein made by the liver that circulates in the blood. Low levels can indicate liver, kidney, or intestinal disease. 🟡🔴🔵

Alkaline Phosphatase (ALP)
Elevations can indicate liver swelling, or decreased bile flow caused by liver disease or endocrine disorders such as thyroid disease, diabetes, Cushing's Disease, or Addison's Disease, and may also be an indicator of certain bone diseases. 🔵🔵

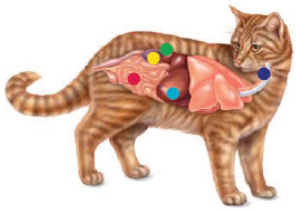
Amylase (AMY)
An enzyme produced to help digest food. Elevated levels can indicate disease of the pancreas, intestines, or kidney. 🟢🟡🔴

Aspartate Aminotransferase (AST)
An enzyme found in the liver, heart, skeletal muscle, kidneys, brain, and red blood cells. AST is an important enzyme in amino acid metabolism and increases can be related to liver or muscle damage. 🔵

Bile Acids (BA)
Vital for identifying and monitoring liver disease, bile acids are one of the best measures of liver function. 🔵

Blood Urea Nitrogen (BUN)
Made by the liver and removed from the body by the kidneys, BUN levels show hydration status and help to evaluate the kidney and liver. 🟡🔵

Calcium (Ca)
Elevations can be an early sign of certain cancers. Imbalanced calcium and phosphorus levels are indicative of certain metabolic disease, such as those of the parathyroid gland and kidney disease. 🟡🔵



Chloride (CL)
Chloride is a major electrolyte, along with Sodium and Potassium. Electrolytes are important to maintain the fluid balance within the body. Vomiting and diarrhoea can lead to loss of chloride, whilst increased chloride could indicate dehydration.

Cholesterol (CHOL)
Changes may be an indication of a variety of disorders, including liver and thyroid disease. Low values may be a sign that the liver is not working well. 🟡🔵🔵

Creatine Kinase (CK)
Creatine Kinase is an enzyme found in the muscles, heart and brain. It can be increased by muscle damage, heavy exercise or by eating a high protein meal. Bites from certain snakes can caused increased CK.

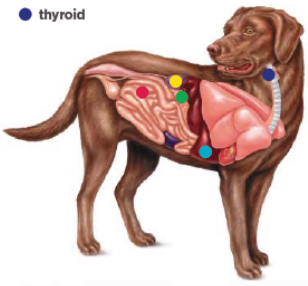
Creatinine (CRE)
An important value to monitor kidney function. 🟡

Gamma Glutamyl Transferase (GGT)
A liver enzyme that helps to differentiate among different types of liver disease. 🔵

Globulin (GLOB)
A body protein that, if elevated, may indicate inflammation or infection.

Glucose (GLU)
Elevated levels can indicate problems, such as diabetes. Low levels can be associated with liver disease or severe infection. 🔵🟢

- 🟢 pancreas
- 🟡 kidney
- 🔴 intestine
- 🔵 liver
- 🔵 thyroid



Phosphorus (PHOS)
Important to monitor for kidney disease, as well as its balance with calcium to monitor many conditions. 🟡

Potassium (K+)
Potassium (K+) levels are important for normal muscle function and heart rate.

Sodium (Na+)
Just like Chloride, Sodium is required to maintain body fluid balance. Increased Sodium can indicate dehydration, whilst decreases could be due to vomiting, diarrhoea or kidney disease. 🟡🔴

Thyroxine (T4)
An excellent test for thyroid gland function in dogs and cats. The thyroid glands play a major role in metabolism. 🔵

Total Bilirubin (TBIL)
An important value to evaluate the liver and when there is a low red blood cell count (anaemia). 🔵

Total Protein (TP)
An estimate of the total protein in the body. Changes can help identify many conditions such as anaemia, and diseases of the liver, kidney, and gastrointestinal tract. 🟡🔴🔵

Total Carbon Dioxide (tCO2)
tCO2 is a measure of the carbon dioxide in the blood and is used, along with electrolytes, to determine the acid-base balance of the body (whether the body is in acidosis or alkalosis). This is important when choosing an intravenous fluid therapy.

Haematology tests

Haematology blood tests, also called the complete blood count (CBC), analyse the cells within the blood. Haematology in an important tool that can detect conditions such as anaemia, inflammation, infection and blood clotting capabilities. Haematology tests may include:

Red Blood Cells (RBC) The total number of red blood cells, which carry oxygen to the tissues of the body and transport carbon dioxide to be exhaled by the lungs. If red blood cells are low this is called anaemia.

Haemoglobin (HGB) Haemoglobin is an iron-containing protein that allows red blood cells to transport oxygen around the body.

Haematocrit (HCT) Also known as Packed Cell Volume (PCV). This measures what percentage of the blood is made up of red blood cells compared to fluid and is useful to assess hydration and diagnose anaemia.

Mean Cell Volume (MCV) The average volume of individual red blood cells.

Mean Corpuscular Haemoglobin (MCH) The average amount of haemoglobin in each red blood cell.

Mean Corpuscular Haemoglobin Concentration (MCHC) The haemoglobin concentration compared to the volume of the red blood cell.

Red Cell Distribution Width (RDW) Measures of the degree of variation in red blood cell size. Low RDW means the cells are uniform in size, high RDW means the cells vary greatly in size.

White blood cells (WBC) Total number of white blood cells (leukocytes), which play a major role in the function of your pet's immune system. Increases could indicate infection or inflammation. There are 5 types of white blood cells:

- Lymphocytes (LYM)
- Monocytes (MON)
- Neutrophils (NEU)
- Eosinophils (EOS)
- Basophils (BAS)

Platelets (PLT) Platelets (also called thrombocytes) are needed to prevent or stop bleeding. Therefore, it is very important to check the platelet levels if a pet is undergoing a surgical procedure.

Mean Platelet Volume (MPV) Average volume of individual platelets.

Platelet Distribution Width (PDW) This measures the uniformity of the platelet size.

Platelet Haematocrit (PCT) This measures what percentage of the blood is made up of platelets compared to fluid.

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