COMPLETE BLOOD COUNT
INTERPRETATION GUIDE

Scroll down or click on the following parameters to quickly access content

Complete Blood Count (CBC)

Hematocrit
Hemoglobin

Red Blood Cell (RBC) Parameters

RBC
MCV (mean cell volume)
MCH (mean cell hemoglobin)
MCHC (mean cell hemoglobin concentration)
RDW (red cell distribution width)
RETIC (reticulocytes)

White Blood Cell (WBC) Parameters

WBC (white blood cells)
Leukocyte Differential
NEU (neutrophils)
LYM (lymphocytes)
MONO (monocytes)
EOS (eosinophils)
BASO (basophils)

Platelet (PLT) Parameters

PLT (platelet)
PCT (platelet hematocrit)
MPV (mean platelet volume)
PDW (platelet distribution width)

See also
Granulocytes, agranulocytes, TNCC, nRBCs
Red Blood Cell Count (RBC)

Description

- Red blood cells (RBCs, erythrocytes, red cells, red corpuscles) are the most numerous and longest lived of the circulating blood cells.
- Erythrocytes contain hemoglobin and are critical in tissue oxygenation and blood acid-base balance.
- Red blood cells in mammals are normally anucleate, biconcave disc-shaped cells (although this may not always be apparent on blood smears from cats). The exception is Camelidae species (camels, llamas, etc.) which have flat, ovoid anucleate cells. Red blood cells in all other vertebrates (birds, reptiles, etc.) are ovoid and nucleated.

Abnormal RBC Shapes

Acanthocyte (spur cell)
Cells that have one to four (sometimes more) variably sized, irregular projections (spurs)
Sometimes seen with liver disease or hemolytic disease

Echinocyte (crenated cell)
Cells that have many, often ten or more, projections that are fairly uniform, small and evenly distributed (similar to cocklebur in cross-section)
Frequently an artifact of slide preparation; may be seen with renal disease (uremia)

Hypochromic cell
Cells that appear paler than normal, indicating less hemoglobin pigment
Iron deficiency

Macrocyte
A cell that is larger than normal
These are young cells seen with increased erythropoietic generation

Microcyte
A cell that is smaller than normal
Variety of causes (e.g., some immune-mediated anemias, iron deficiency)

Ovalocyte
An ovoid cell
Occasionally seen in a variety of anemias; normal cell shape in Camelidae

Schistocyte
A "fragmented"-appearing cell; these are generally smaller and have irregular shapes (e.g., triangular)
Microangiopathic disease (e.g., thrombi, heart valve disease)

Spherocyte
A spherical cell that appears smaller than normal on blood films, with no central pallor and may seem to be somewhat darker than usual
Immune-mediated anemia
**Target cell**

These cells have central and rim areas that appear normally pigmented with an area of pallor in between (i.e., appear like a target). Such cells are thin, the appearance being due to increased membrane relative to cell volume. Low numbers are often incidental; numbers may increase with liver disease; regenerative anemias often have a few target cells present.

*This is not a complete list of causes.

- Red blood cell counts are used as an estimate of the total red cell mass in a patient.
- Erythrocytes are not normally present in body fluids other than the blood (e.g., they are not normal in cerebrospinal fluid, urine, etc.).
- When red blood cell numbers are decreased (or there is a decrease in hemoglobin concentration or hematocrit), this is referred to as anemia.
- When red blood cell numbers are increased, this is referred to as erythrocytosis (also polycythemia).

**Other RBC Morphology Terms**

**Basophilic stippling**

Fine dots, usually more than five, that stain basophilic

Regenerative anemias of a variety of causes, lead poisoning

**Howell Jolly body**

Medium-sized, round, basophilic structure (intermediate in size between a normal metarubricyte nucleus and basophilic stippling)

Occasional HJ bodies are seen in normal animals; numbers increase with regenerative responses and splenic disease

**Heinz body**

A pale-staining area in an erythrocyte, attached to and often slightly distorting the cell membrane

Low to moderate numbers are found in some normal cates. In other species, such as dogs, it may be seen with acetaminophen ingestion, zinc poisoning, etc.

**Polychromasia**

RBCs that appear diffusely more basophilic than normal

Regenerative anemias of a variety of causes

**Nucleated red blood cell (NRBC)**

Red blood cells that still contain a nucleus

Occasional NRBCs may be seen in normal animals (except horses). Numbers increase with regenerative anemia from a variety of causes. Disproportionate increases may be seen with lead poisoning, myeloproliferative disorders, etc.

*This is not a complete list of causes.

**Values Below Reference Range**

**Anemia**

**Common Causes**

Anemia may be caused by one of three general mechanisms: (1) erythrocyte destruction (hemolysis); (2) erythrocyte loss; (3) decreased or defective erythrocyte production. **

- Erythrocyte loss (external or internal)
  - Trauma (e.g., severed blood vessels, rupture of internal organs)
o Gastrointestinal ulcers
o Intestinal parasites (e.g., hookworms)
o Coagulation disorders (e.g., hemophilia, coumarin-type rodenticide ingestion, thrombocytopenia)
o Bleeding neoplasms

- Erythrocyte destruction (hemolysis)
  o Immune-mediated diseases (e.g., idiopathic or drug associated)
  o Hemoparasites (e.g., Babesia, Hemobartonella)
  o Toxins (e.g., acetaminophen, zinc)
  o Mechanical fragmentation (e.g., thrombi, heart valve disease, neoplasms such as hemangiosarcoma)

- Erythrocyte decreased production
  o Chronic disease or inflammation (variety of etiologies either neoplastic, immune-mediated, infectious or organ failure such as renal disease
  o Hormonal (e.g., hypothyroidism, hyperestrogenism)
  o Infectious agents (e.g., feline leukemia virus, ricketsial diseases)

**NOTE:** These are only examples, this is not a complete list of causes.

**Related Findings**

- Reticulocytosis, if present, indicates functioning hematopoietic tissue (primarily bone marrow). It is usually seen when blood loss or hemolysis is the cause of anemia.

- Icterus, or hyperbilirubinemia, may be present. It is usually seen when hemolysis is the cause of anemia (presence or absence depends on the rate and degree of hemolysis). It may also be present in cases when chronic liver disease is a cause of anemia, though such anemias are generally nonregenerative.

- Hypoproteinemia (total protein, albumin) may be seen when the cause of anemia is blood loss.

- Leukopenia, thrombocytopenia or pancytopenia may be present when the cause of anemia is hematopoietic (marrow) failure or with Ehrlichiosis or some cases of splenic disease.

**Other Laboratory Tests**

- Decreased RBC counts should be interpreted in light of the complete blood cell (CBC) count. The mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) are used to establish a morphologic classification of the anemia.

- Platelet count or estimation of platelet numbers. Low platelet counts may indicate the cause of the anemia is due to bleeding or to decreased marrow production of cells (as with Ehrlichiosis).

- Leukocyte (WBC) count. If a leukocytosis is present, the anemia may be due to chronic inflammatory disease or immune-mediated disease. Leukopenia may point toward marrow failure.

- Reticulocyte count. Helps evaluate bone marrow responsiveness. Note, in normal animals, it may take two to four days to see a rise in reticulocyte numbers following onset of anemia.

- Total protein. See related findings above.

- Total, direct and indirect bilirubin. See related findings above.
• Bone marrow aspiration cytology. Helps assess for neoplasia, adequacy of marrow precursor cells, etc.
• Prothrombin time, partial thromboplastin time, PIVKA test. Used when cases of hemophilia or anticoagulant rodenticide ingestion are suspected causes of anemia/bleeding.
• Coombs test, direct. Used when hemolytic anemia is suspected.
• FeLV antigen test
• BUN, creatinine tests on serum. Urinalysis. Used when renal disease is a suspected cause of anemia.
• Lead or zinc tests on blood (if history or RBC morphology suggests ingestion)
• *Hemobartonella, Babesia, Ehrlichia* serologic or PCR testing.

### Values Above Reference Range

#### Common Causes
Erythrocytosis is an increase in the numbers of red blood cells (RBCs) in the blood. It is also referred to as polycythemia, though the term erythrocytosis is more specific and correct. Erythrocytosis may be either relative (pseudo) or absolute. Relative erythrocytosis is due to redistribution of red blood cells or blood plasma without an increase in total number of erythrocytes in the body (red blood cell mass). An absolute erythrocytosis is a true increase in the total number of erythrocytes in the body (increased red blood cell mass).***

- **Relative (pseudo) erythrocytosis**
  - Dehydration
  - Splenic contraction associated with excitement (in some species, mainly dogs)
  - Increased vascular permeability (shock)

- **Absolute erythrocytosis**
  - Anoxia (e.g., due to pulmonary disease, cardiopulmonary perfusion mismatch, such as seen with congenital heart disease, living at high altitudes)
  - Increased erythropoietin production (e.g., renal neoplasms, cysts or hydrenephrosis)
  - Endocrine (e.g., hyperthyroidism, increase in catecholamines as with pheochromocytoma)
  - Polycythemia vera

***NOTE: This is only a partial list of causes.

#### Other Laboratory Tests
- Serum total protein, albumin, sodium and chloride levels (will increase with dehydration)
- Urine specific gravity (increases with dehydration)
- Blood gas analysis (to check for hypoxia)
- Serum thyroxine (T4), particularly in cats, increased levels may cause mild to moderate erythrocytosis
- Serum erythropoietin levels (requires special sample handling, not frequently requested)
- Complete blood count (CBC) to check for increases or possible abnormalities in leukocytes or platelets
- Bone marrow cytology
NOTE: Ultrasound and radiographic evaluation of lungs, heart, adrenals and kidneys are important tools used to further define erythrocytosis.

References
Hematocrit (Hct)

Description

- A hematocrit is the percentage of the blood volume made up by erythrocytes.
- A packed cell volume (PCV) indicates a centrifugal method was used to separate the blood sample into three layers (plasma, buffy coat and packed red cells) at the bottom of a glass tube.
- Modern, automated equipment determines a hematocrit by multiplying the average red cell size (mean corpuscular volume: MCV) by the number of red blood cells (RBC) using the equation: Hct = (RBC x MCV)/10.
- Because of plasma trapping, a PCV is usually slightly higher than an Hct determined by automated equipment. The difference is usually less than 2%, but may approach 4% in some samples. (Example: a single canine EDTA whole-blood sample with a PCV of 48% and an Hct of 46.9%.)

Values Below Reference Range

Common Causes

A decrease in the hematocrit is anemia. More specifically, anemia can be a reduction in the numbers of red blood cells (RBC), the volume of red blood cells (Hct) or the concentration of hemoglobin (Hgb). Anemia may be due to:

- Hemolysis
  - Immune-mediated, hemoparasites, toxins and chemicals, mechanical fragmentation, idiopathic and other causes
- Blood loss
  - Trauma, parasitism, ruptured neoplasms, ulcers, hemophilia, poisons (rodenticide), thrombocytopenia and other causes
  - When there is a rapid loss of blood, the Hct value will not reflect the degree of blood loss until readjustment of the plasma volume has had sufficient time to take place; usually 2–6 hours.
- Decreased or defective erythropoiesis
  - Anemia of chronic disease, renal disease, viral infections (FeLV), rickettsial infections, drugs (including chemotherapeutics), myelophthisis, hypothyroidism, hyperestrogenism, iron deficiency, poisoning, ionizing radiation, idiopathic and other causes
- A hematocrit may be spuriously decreased in very small EDTA samples since the relatively excessive amount of liquid EDTA may both dilute the blood and shrink the red cells.

Related Findings

- Reticulocytosis implies an intact bone marrow and suggests either blood loss or hemolysis as the cause of the anemia
- Icterus suggests hemolysis as the cause of the anemia. In most species, the indirect-acting bilirubin rises before the direct-acting bilirubin following a hemolytic event.
- Hypproteinemia suggests blood loss as the cause of the anemia.
Pancytopenia (neutropenia, anemia and thrombocytopenia) is highly suggestive of bone marrow failure.

Other Laboratory Tests

- A decreased Hct should be evaluated in light of the complete blood cell (CBC) count with particular emphasis on the mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), and neutrophil and platelet counts as a way to come to a morphologic classification of the anemia, to evaluate marrow function and to screen for potential thrombocytopenia as a cause of possible blood loss anemia.

- A reticulocyte count to evaluate the bone marrow response to anemia

- A total protein to help evaluate the patient for possible blood loss

- Total bilirubin and bilirubin fractions in the evaluation of possible hemolytic anemia

- A bone marrow aspiration cytology in a case of an unexplained bicytopenia or in refractory, severe or unexplained anemia. In the dog, a bone marrow cytology can also be used as a rough estimate of iron reserves. In cases of pancytopenia, a bone marrow core biopsy is the preferred sample.

- A coagulation panel in cases of suspected congenital or acquired hemorrhagic disorders, including rodenticide poisoning and disseminated intravascular coagulation (DIC)

- A direct Coombs test in cases suspected of immune-mediated hemolytic anemia

- FeLV antigen test to screen anemic cats for feline leukemia virus infection

- BUN, creatinine and urine specific gravity as part of an evaluation of possible renal failure

- Toxicology testing in cases of suspected lead or zinc (ingested pennies) poisoning

- Serology or PCR testing to confirm hemoparasitism (Babesia, Hemobartonella)

Values Above Reference Range

Common Causes

- An increase in the hematocrit above the reference value is called polycythemia.

- Relative polycythemia may be because of dehydration or internal fluid (plasma) redistribution due to increased vascular permeability, as in cases of shock. Relative polycythemia may also be caused by splenic contraction.

- Absolute polycythemia is an increase in the total RBC mass. Causes include chronic hypoxia, hyperthyroidism, inappropriate erythropoietin secretion due to primary renal disease and red cell neoplasia (polycythemia vera).

Other Laboratory Tests

- Total serum protein, BUN, creatinine and urine specific gravity to evaluate hemoconcentration (dehydration) as a cause of a relative polycythemia

- Blood gas analysis for hypoxia as an appropriate cause of increased erythropoietin leading to an absolute polycythemia

- Serum thyroxine (T4) test in cats suspected of hyperthyroidism and subsequent mild polycythemia

References

Hemoglobin (Hgb)

Description

- Hemoglobin (Hgb) is the predominant protein in blood. Hemoglobin measurements are used as an estimate of the total red cell mass in a patient.

- In some cases, the hemoglobin measurement is superior to the packed cell volume (PCV) or hematocrit (Hct) since neither red cell size changes nor in-vitro hemolysis will alter the hemoglobin concentration.

- Hemoglobin is a large globular protein that is composed of two alpha chains and two beta chains for a total of four iron-containing heme groups bound to four globulin chains.

- Hemoglobin gives blood its characteristic red color and (as oxyhemoglobin) is responsible for oxygen transport by the blood.

- In automatic hematology analyzers, a small aliquot of a blood sample is used for the RBC count. A separate aliquot from that same sample is hemolyzed using a lyse reagent, and the direct measurement of the hemoglobin concentration is made by a spectrophotometer using a 540-nm narrow bandwidth filter.

- In some current analyzers, the hemoglobin concentration is automatically corrected if the white blood cell count (WBC) is >30,000/µL.

Values Below Reference Range

Common Causes
A decrease in the concentration of hemoglobin in the blood is anemia. More specifically, anemia can be a reduction in the numbers of red blood cells (RBC), the volume of red blood cells (Hct) or the concentration of hemoglobin (Hgb). Anemia may be due to:

- Hemolysis
  - Immune-mediated, hemoparasites, toxins and chemicals, mechanical fragmentation, idiopathic and other causes

- Blood loss
  - Trauma, parasitism, ruptured neoplasms, ulcers, hemophilia, poisons (rodenticide), thrombocytopenia and other causes
  - Hemoglobin is not normally found in body fluids other than blood.

- Decreased or defective erythropoiesis
  - Anemia of chronic disease, renal disease, viral infections (FeLV), rickettsial infections, drugs (including chemotherapeutics), myelophthisis, hypothyroidism, hyperestrogenism, iron deficiency, poisoning, ionizing radiation, idiopathic and other causes

Related Findings

- Reticulocytosis
Implies an intact bone marrow and suggests either blood loss or hemolysis as the cause of the anemia

- Icterus
  - Suggests hemolysis as the cause of the anemia. In most species, the indirect-acting bilirubin rises before the direct-acting bilirubin following a hemolytic event.

- Hypoproteinemia
  - Suggests blood loss as the cause of the anemia

- Pancytopenia (neutropenia, anemia and thrombocytopenia)
  - Highly suggestive of bone marrow failure

Other Laboratory Tests

- Complete Blood Count
  - A decreased hemoglobin concentration (anemia) should be evaluated in light of the complete blood cell (CBC) count, with particular emphasis on the mean corpuscular volume (MCV), the mean corpuscular hemoglobin concentration (MCHC), and the neutrophil and platelet counts as a way to come to a morphologic classification of the anemia, to evaluate other marrow cell line production and to screen for potential thrombocytopenia as a cause of possible blood loss anemia.

- Reticulocyte count
  - Evaluates the bone marrow response to anemia

- Total protein
  - Helps evaluate the patient for possible blood loss

- Total bilirubin and bilirubin fractions
  - Evaluates possibility of hemolytic anemia

- Bone marrow aspiration cytology
  - In a case of an unexplained bicytopenia or in refractory, severe or unexplained anemia. In the dog, a bone marrow cytology can also be used as a rough estimate of iron reserves.
  - In cases of pancytopenia, a bone marrow core biopsy is the preferred sample.

- Coagulation panel
  - In cases of suspected congenital or acquired hemorrhagic disorders, including rodenticide poisoning and disseminated intravascular coagulation (DIC)

- Direct Coombs test
  - In cases suspected of immune-mediated hemolytic anemia

- FeLV antigen test
  - Screens anemic cats for feline leukemia virus

- BUN, creatinine and urine specific gravity
Part of an evaluation of possible renal failure

- **Toxicology**
  - Test in cases of suspected lead or zinc (ingested pennies) poisoning

- **Serology or PCR**
  - Confirms hemoparasitism (*Babesia, Hemobartonella*)

### Values Above Reference Range

#### Common Causes

- **Polycythemia**
  - An increase in the hemoglobin content above the reference value is suggestive of polycythemia.
  - Relative polycythemia may be because of dehydration or internal fluid (plasma) redistribution due to increased vascular permeability, as in cases of shock.
  - Relative polycythemia may also be caused by splenic contraction.
  - Absolute polycythemia is an increase in the total RBC mass. Causes include chronic hypoxia, hyperthyroidism, inappropriate erythropoietin secretion due to primary renal disease and red cell neoplasia (polycythemia vera).

- **Spurious increases**
  - Artefactual increases in the hemoglobin measurement occur when "something" interferes with the light path in the automated analyzer.
  - Causes of spuriously increased hemoglobin concentrations include marked lipemia, the administration of synthetic blood substitutes, the presence of Heinz bodies (erythrocyte refractile bodies) and, rarely, extreme leukemia.

- **Hemoglobin in body fluids**
  - Usually an indication of acute or chronic hemorrhage; hemoglobinuria is the presence of free hemoglobin in urine.

- **Hemoglobinuria**
  - In true hemoglobinuria, there is marked intravascular hemolysis where the hemoglobin concentration in plasma has risen to the point that it saturates the plasma haptoglobin-binding capacity and "spills" over into the urine. True hemoglobinuria, therefore, is only found in patients with hemolyzed plasma.
  - In false hemoglobinuria, the hemoglobin comes from erythrocytes in the urine (hematuria) that have hemolyzed there. Hemolysis in the urine is most common in dilute (specific gravity less than 1.008), alkaline urine.
  - Myoglobin may also react with the urine occult blood test pad and may be misinterpreted as hemoglobinuria. Myoglobin, however, is not conserved by haptoglobin, so it does not discolor plasma.

### Other Laboratory Tests

- Total serum protein, BUN, creatinine and urine specific gravity
- Evaluates hemoconcentration (dehydration) as a cause of a relative polycythemia
  - Blood gas analysis
    - For hypoxia as an appropriate cause of increased erythropoietin leading to an absolute polycythemia
  - Serum thyroxine (T4) test
    - In cats suspected of hyperthyroidism and subsequent mild polycythemia

References
Mean Corpuscular Volume (MCV)

Description

- The MCV is the average size (volume) of the red cells in a sample expressed in femtoliters (fL). A femtoliter is 1 x 10^-15 L. Traditionally the mean red cell volume was determined by the equation: 
  \[ MCV = \frac{PCV}{RBC} \times 10 \]
- Modern, automated hematology analyzers measure the MCV directly.
- Since the MCV is the average red cell size, it is a rather insensitive measure of early red cell morphologic changes.

Values Below Reference Range

Common Causes

- A decreased MCV indicates microcytosis.
- Iron deficiency is the most common cause of microcytosis and is generally classified as a microcytic-hypochromic anemia (decreased MCV and decreased MCHC).
- Microcytosis is occasionally found in dogs with portosystemic shunts.
- Immature animals often have smaller red cells (which may be due to a relative iron deficiency)
- Japanese Akita and Shibas dogs normally have microcytic red cells.

Other Laboratory Tests

- Iron deficiency is classically defined as being microcytic hypochromic anemia. In addition to the MCV, other tests that are useful in evaluating a possible iron deficient patient are the Hct, RBC, Hgb and MCHC, and the red cell morphology in a stained blood smear. Many patients that are iron deficient also have a concurrent thrombocytosis. Serum measurement of iron concentration is a relatively insensitive indicator of total body iron stores. Iron stores can also be qualitatively evaluated on cellular bone marrow cytology preparations using special iron stains.
- A bile acid panel or a blood ammonia panel is recommended to help evaluate a patient for a possible portosystemic shunt. The diagnosis of a portosystemic shunt is dependent on identifying the shunt with ultrasonography, contrast radiology or exploratory surgery.

Values Above Reference Range

Common Causes

- An increased MCV indicates macrocytosis.
- A reticulocytosis is the most common cause of a macrocytosis. Regenerative anemias are generally classified as macrocytic-hypochromic (increased MCV, decreased MCHC).
- Some cats infected with the feline leukemia virus have a macrocytic-normochromic anemia. This was once referred to as a "pseudo-B12 deficiency."
- Macrocytosis is a common, normal, finding in some poodles.
- Autoagglutination of red cells is the most common spurious cause of an increased MCV.
- Persistent hypernatremia in cats may cause a spurious increase in the MCV and the Hct when measured by automated equipment.

Other Laboratory Tests

- An increased MCV should be evaluated with the other measured and calculated parameters in a CBC (Hct, RBC, Hgb, MCHC), the red cell morphology on a stained blood smear and a reticulocyte count.
- Cats with an increased MCV should also be evaluated for feline leukemia virus and *Hemobartonella*.

**References**


DeNicola D. Erythrocyte parameter evaluation and the regenerative versus nonregenerative anemia. Presented at: Chicago Veterinary Medical Association Seminar; October 12, 1999; Oak Brook, Il.

Mean Corpuscular Hemoglobin (MCH)

Description
- The mean corpuscular hemoglobin (MCH) value is determined by the equation: MCH = (Hgb/RBC) X 10.
- The MCH is expressed as picograms (pg) of hemoglobin (per average red cell). A picogram is $1 \times 10^{-12}$ gram.
- The MCH value usually parallels the mean corpuscular hemoglobin concentration (MCHC) value and adds little to the interpretation of the hemogram.

Reference

Mean Corpuscular Hemoglobin Concentration (MCHC)

Description

- The mean corpuscular hemoglobin concentration (MCHC) is the ratio of the weight of hemoglobin to the volume of the erythrocyte, and is expressed as either a percentage or in grams per deciliter of red cells (g/dL).
- The MCHC is classically determined by the equation: MCHC = (Hgb/Hct) X 100.
- In automated equipment, however, the Hct is a calculated value based on the RBC and the MCV values, which are directly measured parameters. An MCHC value derived from an automated hematology analyzer, therefore, is based on all three directly measured red cell parameters (Hgb, RBC and MCV) and is affected by an error in any one of these measurements.
- Since the MCHC is the mean value of all of the red cells, it is a relatively insensitive test. It is also possible that multiple processes that affect the MCHC may balance each other out and result in a mean value within the reference range (example: a reticulocytosis, which decreases the MCHC, may be counterbalanced by hemolysis, which elevates the MCHC).

Values Below Reference Range

Hypochromasia

Common Causes

- Reticulocytosis
  - The most common cause of a decreased MCHC is a reticulocytosis because the immature RBC is not fully hemoglobinated when it is released into the circulation.
- Iron deficiency
  - Another cause of a decreased MCHC (hypochromasia)

Other Laboratory Tests

- CBC
  - A decreased MCHC should be evaluated with the other measured and calculated parameters in a CBC (Hct, RBC, Hgb, MCV), the red cell morphology on a stained blood smear and a reticulocyte count.
- Other erythrocyte parameters
  - Iron deficiency is classically defined as being a microcytic-hypochromic anemia. Additional tests to evaluate in a possible iron deficient patient are the Hct, RBC, Hgb, MCV and red cell morphology in a stained blood smear. Many patients that are iron deficient also have a concurrent thrombocytosis.
  - Serum measurement of iron concentration is a relatively insensitive indicator of total body iron stores. Iron stores can be qualitatively evaluated on cellular bone marrow cytology preparations using special stains.

Values Above Reference Range

Common Causes

- Interfering substance or a test error
  - In-vivo or in-vitro hemolysis
  - Lipemia
  - Heinz bodies
  - Autoagglutination of red cells
  - Extreme leukocytosis (leukemic interference)
**References**

DeNicola D. Erythrocyte parameter evaluation and the regenerative versus nonregenerative anemia. Presented at: Chicago Veterinary Medical Association Seminar; October 12, 1999; Oak Brook, Il.


Red Cell Distribution Width (RDW)

Description

- The red cell distribution width is a measure of the degree of variation in red blood cell size (anisocytosis) expressed as a percentage.
- The RDW is an erythrocyte index used to determine the degree of variation in red cell volume.

Values Below Reference Range

Not applicable.

Values Above Reference Range

Common Causes

- The higher the value above the reference interval, the greater the variation in erythrocyte size (i.e., RDW correlates with the degree of anisocytosis for a given sample).
- Increased RDW values are associated with diseases in which there are significant numbers of abnormally sized red blood cells, which includes increased numbers of large red blood cells (macrocytes) and increased numbers of small red blood cells (microcytes).
- Conditions associated with increased numbers of macrocytes:
  - Strongly regenerative anemia
  - Megaloblastosis associated with possible FeLV infection in the cat or myelodysplasia in the dog
- Conditions associated with increased numbers of microcytes:
  - Iron-deficiency anemia
  - Marked mechanical (fragmentation) anemia associated with conditions like disseminated intravascular coagulopathy (DIC)

Other Laboratory Tests

- Complete blood count (CBC), including peripheral blood-film evaluation
- Absolute reticulocyte count

References


Reticulocyte Count

Description
Reticulocytes are immature erythrocytes that lack a nucleus. These immature cells are larger than mature, circulating RBCs and are formed in the bone marrow, where most of the RBC maturation takes place. Numbers of reticulocytes in the peripheral blood of animals varies between species.

- In the healthy dog and cat, extremely few reticulocytes are seen (less than 0.5–1.0% of the erythrocytes).
- In the healthy cow, fewer reticulocytes are seen than compared to the dog and cat.
- In the healthy horse, reticulocytes are very rarely seen and are rarely released from the bone marrow in horses under any condition.

In the cat, two different types of reticulocytes are seen (punctate and aggregate).

- Punctate reticulocytes are not helpful in predicting bone marrow responsiveness with anemia.
- Aggregate reticulocytes are helpful in predicting bone marrow responsiveness with anemia.

Polychromatophils are the peripheral blood counterpart to the reticulocyte when examining routinely stained peripheral blood films.

There are different ways of reporting reticulocyte responses.

- Reticulocyte count (%RETIC)—This is the actual percentage of reticulocytes observed among the non-nucleated erythrocyte population in the peripheral blood.
  Normal %RETIC = <1.0

- Corrected reticulocyte count (CRC)—This is the “corrected” reticulocyte, which takes into consideration the normalization of a change in Hct.
  CRC = (%RETIC) x (Patient Hct ÷ Average normal Hct for that species of animal)
  Normal CRC = 1.0

  Example for a dog:
  %RETIC = 3.0
  Patient Hct = 15%
  Average dog Hct = 45%
  CRC = (3.0) x (15% ÷ 45%) = 1.0

- Absolute reticulocyte count (RETIC)—This is the actual number of reticulocytes per microliter observed among the non-nucleated erythrocyte population in the peripheral blood.
  RETIC = %RETIC x RBC
  Normal dog RETIC = <60,000

  Example for a dog:
  %RETIC = 3.0
  Patient RBC = 3.50 x 10⁶/µL
  RETIC = 0.03 x 3.50 x 10⁶/µL = 1.05 x 10⁶/µL (105,000/µL)
Normal cat RETIC = <50,000

Values Below Reference Range

Common Causes
- A decrease in reticulocytes can indicate bone marrow depression or nonregenerative anemia.
- In species that release reticulocytes when there is a peripheral demand (dog, cat and ruminant), a decreased reticulocyte count is difficult to identify in animals that are not anemic because they would have extremely low numbers of circulating reticulocytes. In addition, the low end of most reference ranges is 0/µL.
  - In health, a within-reference-range reticulocyte count is normal.
  - A lack of a reticulocytosis indicates that there is no evidence of a bone marrow response to a peripheral demand for erythrocytes.
  - In the case of an anemic animal of a species that does demonstrate significant reticulocytosis during regeneration, a lack of a reticulocytosis indicates the anemia is nonregenerative at that time.
  - Extremely low reticulocyte counts (less than 5,000/µL) in the face of anemia is strong support for a nonregenerative anemia associated with either bone marrow failure to produce erythrocytes or ineffective erythropoiesis (dog, cat, ruminant).
- General reticulocyte guidelines (reticulocytes/µL) for the dog and cat:

<table>
<thead>
<tr>
<th>Degree of Regeneration</th>
<th>Dog</th>
<th>Cat</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>&lt;60,000</td>
<td>&lt;15,000</td>
</tr>
<tr>
<td>Slight</td>
<td>150,000–300,000</td>
<td>50,000–100,000</td>
</tr>
<tr>
<td>Moderate</td>
<td>300,000–500,000</td>
<td>100,000–200,000</td>
</tr>
<tr>
<td>Marked</td>
<td>&gt;500,000</td>
<td>&gt;200,000</td>
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Related Findings
No significant polychromasia should be seen on a routinely stained (Romanovsky-type stain) peripheral blood film since polychromatophils correlate well with reticulocytes. The pale blue staining of the cytoplasm correlates to the cytoplasmic RNA and organelles seen as aggregated precipitates in the reticulocytes.

Other Laboratory Tests
- Serial reticulocyte counts and accompanying CBC determinations may be required to accurately assess the capability of the bone marrow to respond; there is a lag period for peripheral blood reticulocytosis because of the finite maturation time for erythrocytes in the bone marrow.
- Bone marrow aspirate should be considered in persistent nonregenerative anemia unless an obvious underlying cause such as renal failure is identified.
- Bone marrow core biopsy may be required to accurately characterize a documented nonregenerative anemia to investigate for potential abnormalities such as myelofibrosis, marrow necrosis, neoplastic infiltrative/proliferative disease, etc.

Values Above Reference Range

Common Causes
- An increase in reticulocytes can indicate a regenerative anemia.
An increase in the reticulocyte count indicates that the bone marrow is responding to a demand for erythrocytes due to a lack of viable red blood cells in circulation. This can be related to either a deficiency of erythrocytes (anemia) or a decreased life span of erythrocytes (hemolytic disease).

- Regenerative anemia—Blood loss or hemolytic anemia with an associated reticulocytosis indicates the presence of a regenerative anemia.
- Reticulocyte response in the peripheral blood has a 2–4-day lag time relative to the onset of demand for increased numbers of erythrocytes because of the 3–5-day maturation time for erythrocytes.
- The degree of reticulocytosis in the more severe anemia may help distinguish blood loss from hemolytic anemia.
  - Intravascular and extravascular hemolytic anemias may have a greater reticulocytosis than blood-loss anemia because of the immediate availability of iron for hemoglobin synthesis, an essential component to erythrocyte maturation.
- During blood-loss anemia, stable forms of iron in the body (hemosiderin stores in macrophages of the bone marrow, spleen, liver, etc.) must be mobilized for hemoglobin synthesis and red blood cell production.
- Reticulocytosis is occasionally seen with various selected conditions not associated with anemia.
  - Compensated hemolytic disease
  - Hyperadrenocorticism
  - Polycythemia—appropriate secondary (high altitude, respiratory disease, etc.)
  - Polycythemia—primary (polycythemia vera)

Related Findings
- Polychromatophils identified on a routinely stained (Romanovsky stain) peripheral blood film correlate with reticulocytes. The pale blue staining of the cytoplasm correlates to the cytoplasmic RNA and organelles seen as aggregated precipitates in the reticulocytes.
- Mean corpuscular volume (MCV) may be increased during reticulocytosis since these immature erythrocyte forms are larger than mature erythrocytes. Increases in MCV will only be seen if significant numbers of reticulocytes are present in circulation.
- Mean corpuscular hemoglobin concentration (MCHC) may be decreased during reticulocytosis since these immature erythrocyte forms do not have their full complement of hemoglobin in the cytoplasm. Increases in MCHC will only be seen when significant numbers of reticulocytes are present in circulation.
- Red cell distribution width (RDW) may be increased during reticulocytosis since the RDW correlates to the degree of anisocytosis present in the RBC population. When there is significant anisocytosis, there is typically a significant degree of reticulocytosis.

Other Laboratory Tests
- Serial reticulocyte counts and accompanying CBC determinations may be required to accurately assess the capability of the bone marrow to respond. There is a lag period for peripheral blood reticulocytosis because of the finite maturation time for erythrocytes in the bone marrow.
- Bone marrow aspirate collection and detailed cytomorphologic evaluation should be considered in persistent nonregenerative anemia unless an obvious underlying cause such as renal failure is identified.
- Bone marrow core biopsy and detailed histologic evaluation of the marrow stromal architecture may be required to accurately characterize a documented nonregenerative anemia to investigate for potential stromal abnormalities such as myelofibrosis, marrow necrosis, neoplastic infiltrative/proliferative disease, etc.

References
DeNicola D. Erythrocyte parameter evaluation and the regenerative versus nonregenerative anemia. Presented at: The Chicago Veterinary Medical Association Seminar, October 12, 1999, Oak Brook, Il.


White Blood Cell Count (WBC)

Description
- The white blood cell (WBC) count is the total number of white blood cells contained in a cubic millimeter (mm³) or microliter (µL) of anticoagulated whole blood.
- Neutrophils, lymphocytes, monocytes, eosinophils and basophils are included in this value.
- Some automated counting instruments and manual methods include nucleated erythrocytes (nRBCs) in this number.
- Equation for correction of WBC count (for presence of nucleated erythrocytes observed per 100 leukocytes):
  \[
  \text{Equation} = \frac{\text{initial WBC count} \times 100}{100 + \text{nRBCs}}
  \]

Values Below Reference Range
Leukopenia
Common Causes
- Decreased production
  - Bone marrow is suppressed, disrupted or destroyed due to toxic, neoplastic or infectious diseases.
- Increased loss or utilization
  - Increased rate of cell emigration from the peripheral blood beyond the rate of production
- Sequestration
  - Collection of cells in an organ system or compartment
- Specific causes depend on the particular cell line affected

Related Findings
Because neutrophils represent the predominant leukocyte in dogs and cats, increases or decreases in the total WBC count often reflect the neutrophil count.

Other Laboratory Tests
- WBC differential
  - The absolute WBC count is the sum of each type of leukocyte per mm³ or µL in the blood sample. The absolute number of each type of leukocyte is calculated by multiplying the percentage of the cell type by the total white blood cell count.

Values Above Reference Range
Leukocytosis
Common Causes
- Inflammatory response
  - Increases in any or all of the leukocyte types can reflect general inflammation or immune stimulation. Increased numbers of a specific leukocyte type can indicate a more specific cause.
- Stress/Corticosteroid response
Increased release of cells from bone marrow, shift of cells from the marginal pool to the circulating pool, and decreased rate of cell emigration from the peripheral blood into the tissues. Mature neutrophils comprise most of the cells. A left shift is not expected.

- **Exercise/Epinephrine response**
  - Shift of cells from the marginal pool to the circulating pool. Transient physiologic leukocytosis is most common in cats. Mature neutrophils and/or lymphocytes comprise most of the cells. A left shift is not expected.

- **Leukemic response**
  - An increased number of a particular leukocyte type, especially an increased number of immature forms, may reflect a neoplastic condition. Increased cell numbers are produced and are released into peripheral blood. Neoplastic cells often have sub optimal performance regarding immune function.

**Related Findings**

- An increased WBC count due to inflammation may include immature forms (left shift) and toxicity.
- An increased WBC count due to leukemia may be associated with varying degrees of anemia, which is usually nonregenerative.

**Other Laboratory Tests**

- WBC differential

**References**


**Neutrophils**

**Description**

- Neutrophils are the most common leukocytes in dogs, cats and horses, but all mammals have neutrophils or their equivalent (e.g., heterophils).
- The primary function of neutrophils is phagocytosis and microbicidal action.
- Neutrophils have a fairly short half-life in the blood (approximately ten hours).
- Neutrophils are one of three types of polymorphonuclear (PMN) cells. The other two are basophils and eosinophils.

**Values Below Reference Range**

**Neutropenia**

**Common Causes**

- Neutropenia is a decrease in the number of neutrophils in the peripheral blood. Leukopenia is a decrease in total number of white blood cells (leukocytes) in the blood. Neutropenia may occur with or without leukopenia. When leukopenia is present, other cell lines (e.g., lymphocytes and monocytes) are also often decreased.
- There are two general causes of neutropenia: (1) decreased production and (2) reduced survival (increased demand).
  - Decreased product may be seen with some viral or other infectious agents (e.g., parvovirus in dogs and cats, *Ehrlichia*, feline leukemia virus, feline immunodeficiency virus). Some drugs, such as estrogen
cyclophosphamide, doxorubicin and methimazole, among others, may result in neutropenia. Idiosyncratic drug reactions such as phenylbutazone in dogs are seen as occasional causes of neutropenia. Myeloproliferative diseases (leukemia) may be associated with neutropenia. Myelofibrosis and myelophthisis may lead to neutropenia. Cyclic hematopoiesis as seen in grey collies also results in periodic neutropenia.

- Increased demand may be due to severe overwhelming infections, particularly in debilitated or malnourished animals. Some bacteria such as \textit{Salmonella} are more frequently associated with this. Neutropenia in these cases often has a concurrent left shift (band neutrophils present) as well as "toxic" change in the neutrophils (see below).

\textbf{NOTE:} If blood is drawn under anesthesia or heavy sedation, a mild neutropenia or leukopenia may develop in some animals.

\textbf{Related Findings}

- Leukopenia (decreased total white blood cell count) is often seen concurrent with neutropenia, though not always.
- A left shift is often present. This is an increase in less mature neutrophils (usually band neutrophils, but sometimes even earlier stages) in the peripheral blood.
- Toxic changes may be present. Toxic neutrophils have increased cytoplasmic basophilia, sometimes foamy cytoplasm or clumped blue-staining reticulum called Dohle bodies. The term "toxic" does not mean that a poison is responsible for the change.

\textbf{Other Laboratory Tests}

- Total WBC (white blood cell) count to check for leukopenia
- RBC (red blood cell) count to check for concurrent anemia
- Platelet count or estimation of numbers to see if there is also thrombocytopenia
- Differential—the relative and absolute differential should be considered to see if only neutrophils are affected or if other cell lines are decreased as well.
- Bone marrow cytology and/or core biopsy and histopath—checks to see if maturation is orderly, if adequate precursor cells are present or for neoplasia, myelofibrosis, etc.
- \textit{Ehrlichia} antibody titer or \textit{Ehrlichia} PCR test, FeLV test or FIV test, depending on species
- Blood culture or culture of lesions or organs
- CBC repeat to see if the neutropenia is transient, persistent or progressive

\textbf{Values Above Reference Range}

\textbf{Neutrophilia}

\textbf{Common Causes}

- Neutrophilia is an increase in the number of neutrophils in the peripheral blood. The increase may be due to physiologic responses, corticosteroids or disease-related.
- Physiologic increase is due to increased heart rate, blood pressure and blood flow. Such increases are common due to epinephrine (and sometimes cortisol) release. Such releases occur when the animal is excited, frightened, convulsing, etc.
- Corticosteroids cause a neutrophilia. Exogenous corticosteroids of any type may produce this. Endogenous corticosteroids in association with Coombs disease, chronic stress, etc. may result in neutrophilia. The degree of neutrophilia is mild to moderate in these cases, with no increase in band neutrophils.
- Inflammation due to a variety of etiologies may result in neutrophilia. Such increases vary from mild to marked. Inflammation may cause neutrophil counts in dogs to sometimes exceed 70,000 per microliter. Such marked increases are often termed "leukemoid." Causes include:
  - Infections, either localized or systemic (e.g., abscess, pyometra, peritonitis, pneumonia)
- Tissue necrosis or damage, such as with organ orion, infarction, neoplastic infiltration
- Hemorrhage, either external or internal
- Hemolysis due to drugs, immune-mediated disease or parasites
- Immune-mediated disease
- Chronic myelogenous leukemia may give rise to marked increases in neutrophils, most of which are mature

Related Findings

- A left shift may or may not be present. This is an increase in the numbers of band neutrophils and sometimes earlier precursor.
- Toxic changes may be present. Toxic neutrophils have increased cytoplasmic basophilia, sometimes foamy cytoplasm or clumped blue-staining reticulum called Dohle bodies. The term "toxic" does not mean that a poison is responsible for the change.

Other Laboratory Tests

- Total WBC (white blood cell) count
- Differential of leukocytes (relative and absolute)
- Serum globulin levels often increase with inflammation
- Bacterial (or fungal) culture of masses or organs
- Blood culture
- Cytology or biopsy and histopath of any masses or enlarged organs
- Bone marrow cytology or core biopsy and histopathology

References


**Lymphocytes**

**Description**
- Lymphocytes are leukocytes that are derived from lymphoid tissues such as lymph nodes, spleen and thymus.
- Mature lymphocytes are approximately 1–1.5 times the size of a red cell, with scant bluish cytoplasm, round to oval nuclei, and aggregated or clumped chromatin.
- Lymphocytes differ from other leukocytes in that after leaving the vascular system, they can recirculate and have a relatively long half-life.
- Lymphocytes constitute a majority of cells in the normal bovine differential, and can occur as small, medium or large cells.
- Their primary function is humoral and cell-mediated immunity.

**Values Below Reference Range**

**Lymphopenia**

**Common Causes**
- Corticoid induced redistribution
- Acute systemic infection
- Viral infections
- Loss of lymphocyte-rich lymph such as during lymphangiecasis
- Immunosuppressive therapy
- Hereditary immunodeficiency

**Related Findings**
- Corticoid-induced lymphopenia is the most common cause.
- Concurrent mature neutrophilia is common.

**Other Laboratory Tests**
- Differential WBC count
- Alkaline phosphatase (ALP)
  - This enzyme is composed of an isoenzyme subunit that is corticosteroid-inducible.

**Values Above Reference Range**

**Lymphocytosis**

**Common Causes**
- Epinephrine effects
  - More common in cats
- Antigenic stimulation
- Lymphocytic leukemia
• Immature animals normally have a higher lymphocyte count

**Related Findings**

• Epinephrine effects often also have a mature neutrophilia.
• Immune stimulation will occasionally have larger and/or reactive lymphocytes.
• Lymphocytic leukemias can consist of primarily small, mature cells and immature cells or lymphoblasts, or a combination of both.

**Other Laboratory Tests**

• Globulin
• Rickettsial serologies in dogs
• FIV/FeLV serology in cats
• Bone marrow aspirate

**References**
Monocytes

Description
- Monocytes comprise the largest cell present in normal peripheral blood.
- They have abundant cytoplasm, which is blue-gray and may or may not be vacuolated.
- Their nuclei are round to oval, bi-lobed or tri-lobed, and are often indented or clefted.
- Monocytes differentiate into macrophages after they leave the peripheral blood vasculature, and they do not recirculate.
- The primary function of monocytes is phagocytosis of particulate matter and effete cells.
- They also play a major role in the immune system as a source of many cytokines important in immunoregulation, and processing of foreign substances into antigenic material to present to immunocompetent lymphocytes.

Values Below Reference Range
Common Causes
Not clinically relevant

Values Above Reference Range
Monocytosis
Common Causes
- Immune stimulation (including suppurative, pyogranulomatous, necrotic, malignant, hemorrhagic, hemolytic or immune-mediated diseases)
- Corticosteroid or stress-induced
- Seen during recovery of neutropenia
- Bacteremia

Related Findings
- Monocytosis is most often accompanied with neutrophilia, which may have an associated left shift and cellular toxicity.

Other Laboratory Tests
- WBC count
- Differential
- Globulin

References

Eosinophils

Description

- Eosinophils are a type of leukocyte (white blood cell) named for their characteristic cytoplasmic granules.
- Their granules stain variably eosinophilic, depending on the species.
- The granule shape is species-specific. They are large, round and uniform in the horse, rod-shaped and not as bright in the cat; dogs have varying numbers and sizes of granules.
- The granules contain enzymes and other substances that are important to their protective function.
- These cells are active in the killing of helminthes, and also in the regulation of mast cells.

Values Below Reference Range

Common Causes

- Normal ranges commonly approach zero.
- Corticosteroids (endogenous and exogenous) tend to decrease eosinophil numbers.

Related Findings

- Corticosteroids also will cause lymphopenia, neutrophilia and monocytosis.
- Clinical findings associated with excess corticosteroids (hyperadrenocorticism) include polyuria, polydipsia, polyphagia, abdominal enlargement and alopecia.

Values Above Reference Range

Common Causes

- Parasitic infections
- Hypersensitivity response
- Eosinophilic granuloma complex
- Uncommon causes:
  - Neoplasia: mast cell tumor and lymphoma most commonly
  - Hypoadrenocorticism
  - Chronic eosinophilic leukemia
  - Hypereosinophilic syndrome

Related Findings

- Endoparasites (heartworms, hookworms) or ectoparasites (fleas) may be present.
- Examination for possible hypersensitivity sites (skin, lung, gastrointestinal tract and reproductive tract) may be helpful.
Other Laboratory Tests

- Heartworm antigen and concentrated filarial tests
- Fecal examination for ova and larva
- Serum chemistry and electrolytes

Reference
Basophils

Description
- Basophils are most often in low numbers in normal differentials.
- The granules of basophils are round and stain metachromatically or dark.
- Mature basophils in cats have very lightly staining granules.
- Granules are abundant in most species except for the dog.
- The most prominent constituents of basophil granules are histamine and heparin.
- They function as primary mediators of inflammation, and are implicated in hypersensitivity responses.

Values Below Reference Range
Common Causes
- Not clinically important
  - The normal differential for most species includes zero in the reference range.

Values Above Reference Range
Common Causes
- Immune hypersensitivity responses
  - Parasitic, allergic responses/hypersensitivities
- Nephrotic syndrome
- Endocrine diseases
- Hypothyroidism

Related Findings
- Basophilia is most often accompanied by eosinophilia
  - Both are stimulated by IgE-generating disorders

Other Laboratory Tests
- Differential white blood cell count
- Endocrine function tests
- Thyroid function tests

Reference
Platelets

Description

- Platelets are involved in primary hemostasis, specifically via interaction between platelets and blood vessel walls.
- Automated hematology instruments can be used to count platelets, but caution is warranted since post-collection platelet clumping can falsely decrease values.
- Giant platelets observed in some cats can be excluded from the automated count and this can also falsely decrease values.
- A manual platelet count is advised if clumping or a large proportion of giant platelets is noted via a peripheral blood smear.

Values Below Reference Range

Common Causes

- Increased consumption (immune-mediated)
  - Primary—autoimmune, idiopathic
  - Secondary—neoplasia, drug-induced, caccine (i.e., modified-live canine distemper virus), infection (viral, bacterial, protozoal and rickettsial)
- Increased consumption (non-immune causes)
  - Coagulopathy—rodenticide toxicosis, DIC
  - Vasculitis—infectious
  - Premature platelet activation—IV catheter, drug induced, infection
- Decreased production

Related Findings

- Bleeding related to thrombocytopenia typically doesn’t occur until platelet counts reach 50,000 to 10,000 platelets/µL.
- If clinical signs include ecchymosis/petechia or bleeding from surfaces, and the platelet count is within the reference values, then rule out platelet dysfunction via a buccal mucosal bleeding time (BMBT) test.
- In horses, EDTA anticoagulants can allow platelets to aggregate after collection, falsely decreasing the platelet count.

Other Laboratory Tests

- CBC with pathologist review, biochemistry profile and urinalysis
- Coagulation profile—manual platelet count, PT, PTT, fibrinogen, fibrin split products (FDP), antithrombin III (ATIII)
- Buccal mucosal bleeding time (BMBT) test and von Willebrand’s factor assay
- Bone marrow aspirate examination

Values Above Reference Range
Common Causes

- Primary
  - Megakaryocytic neoplasia (rare)

- Reactive or secondary
  - Chronic hemorrhage—frequently seen with iron-deficiency anemia
  - Severe inflammatory diseases—gastrointestinal (pancreatitis, inflammatory bowel disease), pulmonary and arthritis
  - Neoplasia—hematopoietic (lymphoma) and nonhematopoietic
  - Endocrine disorders—hyperadrenocorticism, diabetes mellitus, hypothyroidism
  - Drug-induced—glucocorticoid therapy, Vincristine therapy
  - Immune-mediated—immune-mediated (IMHA), in response to immune-mediated thrombocytopenia (IMT)
  - Trauma—fractures and diaphragmatic hernias
  - Post-splenectomy

Related Findings

- The risk of thrombosis and bleeding may increase when platelet count is greater than 1,000,000 platelets/µL.

Other Laboratory Tests

- CBC with pathologist review, biochemistry profile and urinalysis
- Bone marrow aspirate examination

References

Mean Platelet Volume (MPV)

**Description**
The mean platelet volume is analogous to the mean red cell volume (MCV) and is the average size of a single platelet expressed in femtoliters (fL = 10^{-15} L).

**Values Below Reference Range**
**Common Causes**
- A decreased MPV indicates decreased mean platelet size (microplatelets), which may be an indication of immune-mediated attack against platelets.
- A decreased MPV has been associated with early immune-mediated thrombocytopenia.
- Small platelets have also been found in some animals with decreased thrombopoiesis (bone marrow failure).

**Other Laboratory Tests**
- Platelet count (PLT)
- Complete blood count (CBC), including peripheral blood-film evaluation

**Values Above Reference Range**
**Common Causes**
- The most common cause of increased MPV is platelet aggregation in the sample tube.
- An increased MPV indicates that mean platelet size is increased (macroplatelets), which is usually an indication of immature or reactive platelets responding to increased thrombopoiesis.
- Following collection, individual platelets swell over time.
- An increased MPV implies the presence of larger platelets. This has been associated with an increased rate of thrombopoiesis due to a peripheral demand for platelets.
- Cavalier King Charles spaniels have a hereditary macrothrombocytopenic disorder.

**Other Laboratory Tests**
- Platelet count (PLT)
- Complete blood count (CBC), including peripheral blood-film evaluation
- Coagulation panel

**References**


Platelet Distribution Width (PDW)

Description

- The platelet distribution width is the coefficient of variation of platelet size multiplied by 100 and expressed as a percentage value.
- The PDW is an objective measure of variation of platelet size, similar to the red blood cell distribution width (RDW), which is an objective measure of variation (anisocytosis) of red blood cells.
- PDW is generally greater in cats than in dogs.
- The utility of the PDW has not been extensively evaluated in veterinary medicine.

Values Below Reference Range

Not applicable. There is no disease state associated with uniform-sized platelets.

Values Above Reference Range

Common Causes

Increased PDW values are most commonly associated with diseases in which there are significant numbers of large platelets suggesting a possible increase in the rate of thrombopoiesis by the bone marrow in response to a peripheral demand for platelets.

Other Laboratory Tests

- Complete blood count (CBC), including peripheral blood-film evaluation
- Mean platelet volume (MPV)
- Platelet count (PLT)

References


Platelet Hematocrit (Pct)

Description

- The Pct is a measure of the proportion of the volume of blood taken up by platelets. It is derived from the platelet count and the mean platelet volume, similar to the way the hematocrit is derived from the red blood cell (RBC) count and mean red cell volume (MCV).
- The Pct is not as useful as the platelet count (PLT) in determining thrombocytopenia or thrombocytosis, but has a similar interpretation as PLT.

Values Below Reference Range

Common Causes
- A decreased Pct associated with thrombocytopenia may be due to one of three mechanisms:
  - Decreased production—bone marrow failure or ineffective thrombopoiesis
  - Increased peripheral utilization or loss—coagulopathy such as disseminated intravascular coagulopathy, inflammatory disease, hemorrhage
  - Destruction—immune-mediated thrombocytopenia, infectious disease

Other Laboratory Tests
- Platelet count
- Complete blood count (CBC), including peripheral blood-film evaluation
- Coagulation panel
- Potential bone marrow aspirate for cytologic evaluation and/or bone marrow core biopsy for histologic evaluation if there is persistent thrombocytopenia associated with suspected bone-marrow failure

Values Above Reference Range

Common Causes
- An increased Pct is typically associated with thrombocytosis
  - Reactive thrombocytosis—secondary
    - Iron deficiency
    - Recovery (rebound) from thrombocytopenia
    - Post-splenectomy
    - Inflammation
  - Hemic neoplasia—primary
    - Essential thrombocythemia and other myeloproliferative diseases
    - Acute megakaryocytic leukemia

Other Laboratory Tests
- Platelet count (PLT)
- Complete blood count (CBC), including peripheral blood-film evaluation
- Bone marrow aspirate cytologic and core biopsy histologic evaluation

References


Agranulocytes

Description

- Nucleated cells, including all nucleated cells not included in the “granulocyte” category—lymphocytes, monocytes, macrophages, mesothelial cells, neoplastic cells, etc.

Values Below or Within the Reference Interval

- No reference intervals are typically reported for fluid analyses because they are species and fluid origin specific.
- Low agranulocyte counts (less than 500 cells/µL) are typical for normal fluids regardless of their origin.
- Cerebrospinal fluid normally has a total nucleated cell count (TNCC) less than 5 cells/µL.
- Microscopic examination of cytologic specimens is essential for proper cell characterization (degeneration, presence of organisms, etc.) or specific agranulocyte type identification (lymphocyte, monocyte, macrophage, mesothelial cell, neoplastic cell, etc.).

Common Causes

- Normal finding for most fluids

Possible Related Findings

- Normal to near normal cytologic findings on fluid analysis
- Fluid total protein content less than 3.0 g/dL if total nucleated cell count is low and fluid is either normal or transudate

Other Diagnostic Tests

- Fluid total protein measurement
- Fluid cytologic evaluation
- Clinical chemistry profile
- Complete urinalysis
- Diagnostic imaging evaluation
- Microbial culture and sensitivity

Values Above the Reference Interval

- No reference intervals are typically reported for fluid analyses because they are species and fluid origin specific.
- A high agranulocyte count (more than 500–1,000 cells/µL) is considered abnormal for most fluids.
- Cerebrospinal fluid with agranulocyte counts greater than 5 cells/µL is generally considered abnormally high.
- Microscopic examination of cytologic specimens is essential for proper cell characterization (degeneration, presence of organisms, etc.) or specific agranulocyte type identification (lymphocyte, monocyte, macrophage, mesothelial cell, neoplastic cell, etc.).

Common Causes
• Abnormal finding for most fluids
• Modified transudate associated with cardiac insufficiency (passive congestion), lymphatic obstruction, etc.
• Exudate associated with active inflammatory disease of infectious or noninfectious cause
• Neoplastic effusion with active inflammatory disease
• Hemorrhagic effusion with active inflammatory disease

Possible Related Findings

• Abnormal cytologic findings on fluid analysis—inflammatory cells, increased numbers of normal cells for a particular fluid, neoplastic cells
• Potential numerous monocytes/macrophages in various stages of activation with possible active phagocytosis
• Presence of other active inflammatory disease with monocytes/macrophages functionally cleaning up the cellular debris or tissue necrosis
• Inflammatory leukogram on complete blood count (CBC)
• Hyperproteinemia with hyperglobulinemia on clinical chemistry profile

Other Diagnostic Tests

• Fluid total protein measurement
• Fluid cytologic evaluation
• Clinical chemistry profile
• Complete urinalysis
• Diagnostic imaging evaluation
• Microbial culture and sensitivity

References


Granulocytes

**Description**

- Nucleated cells, including all three granulocyte populations—neutrophils, eosinophils and basophils
- Some analyzers (IDEXX VetAutoread and mpedance analyzers) cannot consistently differentiate the different types of granulocytes and only report “Granulocyte.”

**Values Below or Within the Reference Interval**

- Reference intervals are provided for complete blood counts by various hematology analyzers.
- No reference intervals are typically reported for fluid analyses because they are species and fluid origin specific.
- Low granulocytes counts (less than 500 cells/µL) are typical for normal fluids regardless of their origin.
- Cerebrospinal fluid normally has a total nucleated cell count (TNCC) less than 5 cells/µL.
- Microscopic examination of cytologic specimens is essential for proper cell characterization (degeneration, presence of organisms, etc.) or specific granulocyte type identification (neutrophil, eosinophil, or basophil).

**Common Causes**

- Normal finding for most fluids
- Fluid accumulations as a result of processes other than neutrophilic inflammation (chylothorax, transudate, neoplastic effusion, etc.)

**Possible Related Findings**

- Normal to near normal cytologic findings on fluid analysis
- Fluid total protein content less than 3.0 g/dL if total nucleated cell count is low and fluid is either normal or transudate

**Other Diagnostic Tests**

- Fluid total protein measurement
- Fluid cytologic evaluation
- Clinical chemistry profile
- Complete urinalysis
- Diagnostic imaging evaluation
- Microbial culture and sensitivity

**Values Above the Reference Interval**

- Reference intervals are provided for complete blood counts by various hematology analyzers.
- No reference intervals are typically reported for fluid analyses since they are species and fluid origin specific.
- A high granulocyte count (more than 500–1,000 cells/µL) is considered abnormal for most fluids.
- Cerebrospinal fluid with granulocyte counts greater than 5 cells/µL is generally considered abnormally high.
• Microscopic examination of cytologic specimens is essential for proper cell characterization (degeneration, presence of organisms, etc.) or specific granulocyte type identification (neutrophil, eosinophil or basophil).

Common Causes

• Abnormal finding for most fluids
• Modified transudate associated with cardiac insufficiency (passive congestion), lymphatic obstruction, etc.
• Exudate associated with active inflammatory disease of infectious or noninfectious cause
• Neoplastic effusion with active inflammatory disease
• Hemorrhagic effusion with active inflammatory disease

Possible Related Findings

• Abnormal cytologic findings on fluid analysis—-inflammatory cells, increased numbers of normal cells for a particular fluid, neoplastic cells
• Potential degenerative changes in neutrophils associated with septic inflammatory disease
• Eosinophils associated with parasitic, hypersensitivity, and other conditions
• Inflammatory leukogram on complete blood count (CBC)
• Hyperproteinemia with hyperglobulinemia on clinical chemistry profile

Other Laboratory Findings

• Fluid total protein measurement
• Fluid cytologic evaluation
• Clinical chemistry profile
• Complete urinalysis
• Diagnostic imaging evaluation
• Microbial culture and sensitivity

References


Nucleated Red Blood Cells

Description

- Synonyms are nRBCs and metarubricytes.
- Metarubricytes and rubricytes are infrequently present in circulation of normal adult mammals.
- IDEXX Reference Laboratories, circulating nRBCs are counted separately from the leukocyte cell differential and reported as number of nRBCs per 100 white blood cells (WBCs).
- ProCyte Dx, circulating nRBCs are identified within a sample during the WBC analysis and reported as “Suspect presence.”

Common Causes of Decreased nRBCs

- Absence of circulating nRBCs is a normal finding in healthy mammals.

Common Causes of Increased nRBCs

- Bone marrow damage secondary to:
  - Hypoxia
  - Endotoxemia/septicemia
  - FeLV
  - Certain drugs (e.g., cephalosporin)
  - Trauma (e.g., fractures)
  - Myelophthisis (e.g., myelodysplastic syndrome, leukemia, metastatic neoplasia, myelofibrosis, necrosis, etc.)
  - Heat stroke
- Strongly regenerative anemia with extramedullary hematopoiesis
- Lead toxicity
- Iron or copper deficiency
- Splenic disease, splenectomy
- Hereditary macrocytosis of poodles

Other Diagnostic Tests

- Complete blood count (CBC) and reticulocyte count
- FeLV testing (especially by IFA of whole blood or bone marrow)
- Cytologic and histologic core biopsy examination of the bone marrow
- Thoracic radiographs
- Abdominal ultrasound
- Splenic aspiration, if indicated
- Lead levels

References:


Total Nucleated Cell Count

Description

- Total nucleated cell count (TNCC) is a count of all nucleated cells in a fluid, including white blood cells, nucleated red blood cells, and both benign and malignant somatic cells (mesothelial cells, epithelial cells, etc.).
- Some automated analyzers do not include nucleated red blood cells in this number.
- The TNCC is reported in numbers of cells per microliter.

Values Below or Within the Reference Interval

- No reference intervals are typically reported for fluid analyses because they are species and fluid origin specific.
- A low (less than 500–1,000 cells/µL) is considered normal for most fluids.
- Cerebrospinal fluid normally has a TNCC less than 5 cells/µL.
- Microscopic examination of cytologic specimens is essential for proper cell characterization (degeneration, presence of organisms, etc.) or identification (inflammatory cells, normal cells for a specific fluid, neoplastic cells, etc.)

Common Causes

- Normal finding for most fluids
- Pure transudate associated with hypoalbuminemia (protein-losing nephropathy, protein-losing enteropathy, hepatic insufficiency, etc.)
- Modified transudate associated with cardiac insufficiency (passive congestion), lymphatic obstruction, etc.

Possible Related Findings

- Normal to near normal cytologic findings on fluid analysis
- Hypoalbuminemia on clinical chemistry profile—protein-losing nephropathy, hepatic insufficiency
- Panhypoproteinemia on clinical chemistry profile—protein-losing enteropathy
- Proteinuria and increased protein:creatinine ratio—protein-losing nephropathy

Other Diagnostic Tests

- Fluid total protein measurement
- Fluid cytologic evaluation
- Clinical chemistry profile
- Complete urinalysis
- Diagnostic imaging evaluation
- Microbial culture and sensitivity

Values Above the Reference Interval
No reference intervals are typically reported for fluid analyses because they are species and fluid origin specific.

- A high TNCC (less than 1,000 cells/µL) is considered abnormal for most fluids.
- Cerebrospinal fluid with TNCC greater than 5 cells/µL is generally considered abnormally high.
- Microscopic examination of cytologic specimens is essential for proper cell characterization (degeneration, presence of organisms, etc.) or identification (inflammatory cells, normal cells for a specific fluid, neoplastic cells, etc.)

**Common Causes**

- Abnormal finding for most fluids
- Modified transudate associated with cardiac insufficiency (passive congestion), lymphatic obstruction, etc.
- Exudate associated with active inflammatory disease of infectious or noninfectious cause
- Neoplastic effusion with or without active inflammatory disease
- Hemorrhagic effusion with or without active inflammatory disease

**Possible Related Findings**

- Abnormal cytologic findings on fluid analysis—inflammatory cells, increased numbers of normal cells for a particular fluid, neoplastic cells
- Inflammatory leukogram on complete blood count (CBC)
- Hyperproteinemia with hyperglobulinemia on clinical chemistry profile

**Other Diagnostic Tests**

- Fluid total protein measurement
- Fluid cytologic evaluation
- Clinical chemistry profile
- Complete urinalysis
- Diagnostic imaging evaluation
- Microbial culture and sensitivity

**References**


Band Neutrophils

Description

- Band neutrophils (BANDS) are an immature stage of development of the neutrophil.
- BANDS generally have a curved nucleus of nearly uniform thickness in which the sides are approximately parallel to one another throughout the entire length of the nucleus; slight indentation of the nucleus is possible.

Common Causes of Decreased Bands

The normal reference interval for most animals includes no or only extremely few bands (less than 300/μL).

Common Causes of Increased Bands (Left Shift)

- Inflammatory response (most common)
- Pyogenic bacteria/pyometra, pyelonephritis, pyothorax, septic abdomen, prostatitis, sepsis, endotoxins
- Fungal infection
- Immune-mediated disease/immune-mediated hemolytic anemia (IMHA)
- Necrosis
- Neoplasia

Other Diagnostic Tests

- Complete blood count (CBC)—If immature neutrophil forms outnumber mature forms, the left shift is commonly termed degenerative and this may indicate severe overwhelming inflammation or bone marrow failure
- Blood smear evaluation—Observe cells for evidence of toxicity, which supports severe inflammation or possible infectious (bacterial) causes if moderate to marked; rarely, infectious organisms may be noted
- Chemistry profile
- Bacterial culture and susceptibility, if indicated
- Needle aspirate and cytology, if indicated
- Imaging (chest radiographs, abdominal radiographs and/or abdominal ultrasound), if indicated
- Fungal serology/antigen testing, if indicated

References:

