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Blood Test Results - But What Does It Mean?

Most days my electronic mail box brings at least one such plaintive cry from someone who has got hold of their dog's blood results and is now struggling to understand what on earth they might indicate, with their crazy acronyms and values that are too high or too low, sometimes seemingly way out of the normal. This can be one of those cases where a little knowledge is a very dangerous thing. It can be highly significant if certain values are even slightly outside the norm, whereas others have to be many times removed for it to be of any concern whatever. Even normal values taken in conjunction with other normal values can be significant as they trend in one direction or another. Your veterinarian may want to follow these values over time and repeat certain parts of the blood work or even the whole thing. Blood results should never be interpreted without regard to the physical and mental appearance of the dog. It is always a good idea to get annual blood work done on your healthy Beardie. Some dogs may have one or more values that are outside of the laboratory normal, but this can be quite normal for that dog. It will save a lot of time if you aren't scurrying off after red herrings when he gets sick.

The normal values for each lab test may vary from laboratory to laboratory. They are established by measuring the parameters from a number of apparently normal healthy dogs. They do not usually take into consideration breed, sex, neuter status or size. They will consider species, so a dog's blood should never be sent to a human lab. An individual substance may be measured using different tests in some cases in different laboratories.

If your dog is taking any drugs this should be noted on the submission as certain drugs will affect laboratory results. If you are giving your dog any drugs let your veterinarian know, especially if s/he didn't prescribe them. It is generally best, unless otherwise requested, to fast your dog prior to drawing blood. Fat in the blood - lipemia - can affect a number of levels. Some levels will also be affected by hemolysis. This is the result of red blood cells being broken and their contents being lost into the serum. To avoid hemolysis your veterinarian will usually remove the stopper from the vacutainer as well as the needle from the syringe, and not expel the contents of the syringe too fast.

An informed client is a boon to the veterinarian. Obviously, nothing I write should be used to diagnose your Beardie's condition. It may help you ask the right questions or understand your veterinarian's concerns, but nothing more.

Normally when we discuss blood work we mean two specific groups of tests. The Complete Blood Count (CBC) requires whole blood. It is just as it says a numerical count of the various cell types found in the blood. The biochemistry profile is performed on serum - the supernatant part of the blood that rises to the surface after the cells have sunk to the



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bottom when the blood is spun in a centrifuge. If the serum is pink it indicates hemolysis, if it is milky or cloudy it indicates lipemia. Hemolysis can alter the results for amylase, lipase, ALT, AST, calcium and phosphorus, while lipemia can affect glucose, sodium, potassium and protein. Your veterinarian may order other more specific blood work, but these are the basic tests I will be covering in this article.

Complete Blood Count

The CBC measures the number of cells of different types circulating in the blood. There are three basic types, red cells, white cells and platelets. Red cells are made in the bone marrow (the soft center of the bones). Their function is to carry oxygen from the lungs to the cells throughout the body. They are removed from the blood by the spleen and liver. If a Bearded Collie has too few red cells it is anemic, too many and it has a condition called polycythemia. Anemia can occur if red cells are lost to either internal or external bleeding; or if they are destroyed earlier than normal (hemolysis). It may also be the result of insufficient production by the bone marrow. Polycythemia is less common, and usually is the result of dehydration. Animals living at higher elevations make more red cells to compensate for the lower amounts of oxygen in the air. As well as the absolute number of red cells, the CBC will include the hematocrit (Hct) or packed cell volume (PCV) – the percentage of red cells in the blood sample. Blood is spun in very thin tubes, and the red cells settle to the bottom. Above them is the small “buffy” coat layer of white cells and above that the plasma which should be clear and colorless. Clear yellow plasma indicates liver disease – jaundice, white opaque plasma indicates lipemia, and pink to red clear plasma the presence of hemoglobin from lysed red cells. Hemoglobin concentration (Hb) is also measured. Hemoglobin is the substance in the red cell that carries the oxygen. Mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) are all used to help classify anemia, albeit the most useful measure of anemia is the reticulocyte count. Reticulocytes are immature red cells that still contain a nucleus. In anemia they may be released prematurely to help meet the animal’s need for oxygen. You need the absolute reticulocyte count not the proportion. As the numbers of adult red cells drop the proportion of reticulocytes will rise, and so be less informative.

There are several different kinds of white blood cells or leukocytes. The CBC will usually report the percentage as well as the absolute number. The latter is always the more important number. White cells are also made in the bone marrow. The most numerous white cell group are the neutrophils. They are phagocytes – cells that can engulf and digest foreign substances, and their primary function is to destroy microbes. They secrete various substances to help with this, and can also pass through cell walls, attracted to the foreign invaders. Increased numbers of neutrophils indicate inflammation, infection by bacteria, distemper virus, fungi, some parasites, as well as immune mediated disease, necrosis, endotoxins, foreign bodies, hemorrhage, hemolysis and Rocky Mountain Spotted Fever.



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Prednisone and other corticosteroid drugs can increase neutrophil numbers, by reducing their stickiness and random migration from blood to tissues. In general, the response is greatest if the infection is localized (pyometra for example) rather than generalized. Numbers are low if destruction exceeds production. This can result from massive utilization but most often is due to decreased production or decreased survival. Chemotherapy, leukemia, ehrlichiosis, parvovirus, immune mediated diseases, endotoxins or an overwhelming sepsis could cause this. Lymphocytes are found in lymph nodes, spleen, thymus, tonsils, lymphoid tissue in the gastrointestinal tract and respiratory system and bone marrow as well as the blood. While they cannot be differentiated morphologically they are of two types T lymphocytes that mature in the thymus and are involved in cell-mediated immunity and B-lymphocytes that function as antibodies in the blood. They are the most long lived white cells and are unique in that they recirculate back into the blood from the tissues. Recirculation is the process most likely to influence the number of lymphocytes found in the blood. Blood count correlates poorly with enlargement of the lymph nodes. Increased numbers are occasionally seen during chronic infections. Lymphopenia (low numbers) are relatively common in sick animals, however. Stress mediated by corticosteroids (natural or drugs) causes lymphocytes to move from the blood into lymphoid tissue. This effect is maximal 4 to 8 hours after the appearance of the corticosteroids. Acute infection, immunosuppression, acquired deficiency as well as loss or damage to lymph tissue can all reduce lymphocyte numbers. In puppies, lymphocytes may be elevated due to infection.

Monocytes usually parallel neutrophils and increase in infection as well as in response to corticosteroids. Monocytes transform into macrophages after a time in circulation, these are large efficient macrophages with lots more granules and proteolytic enzymes than monocytes. Macrophages clean out any foreign particles or dead cells, but are less responsive to infection than neutrophils. They also present foreign substances to lymphocytes in a form more likely to elicit an immune response. Reduced numbers of monocytes are not clinically significant. Eosinophils are attracted to substances released by mast cells, and inhibit their further release limiting or delaying allergic or anaphylactic reactions. Increased level is usually associated with parasitic infection or hypersensitivity. Reduced numbers can be the result of an acute infection or the presence of corticosteroids. Basophils are usually quite rare. Seeing them is therefore quite significant. They tend to parallel eosinophils, and tend to increase in dirofilariasis the early stage of heartworm. If eosinophil levels are normal but basophil levels are high, serious chronic disease should be investigated.

Platelets, also known as thrombocytes, stick to exposed collagen within seconds after injury and help to form clots to prevent internal and external bleeding. Reduced numbers indicate either bone marrow damage or increased rate of destruction. The two major causes of destruction are immune-mediated thrombocytopenia (ITP), which may be secondary to tick borne and other infections, or disseminated intravascular coagulation (DIC), a complex and



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usually terminal condition in which blood clots throughout the body as the result of a number of serious conditions. Platelet numbers have to drop dramatically before you see spontaneous bruising – including pinpoint petechiation – and bleeding.

A blood smear will be examined microscopically not only as confirmation of the machine generated cell numbers, but also to look for parasites, as well as abnormal cell shapes and arrangements. Platelets may clump in samples giving false low readings and the blood smear will determine whether adequate numbers are indeed present.

The Biochemistry Profile

The levels of a variety of enzymes, electrolytes and other substances are measured in the blood serum. Serum is the clear (hopefully) fluid left after the blood cells have been allowed to clot. Together with urinalysis it provides an overview of the health and function of many of the body organs. The tests included in the profile can vary. Idexx, the laboratory I use, offers a wellness check of 11 substances, but also offers tests for 21, 25 and 27 substances as well as a multitude of add-on tests. Common tests are presented here.

Albumin is a small protein produced by the liver. Albumin helps to hold water in the blood vessels; if albumin levels drop, fluid leaks out of the blood as it is pumped through the body and accumulates in body cavities (e.g. ascites) or in tissues as edema. Albumin is decreased due to intestinal malabsorption or malnutrition; exocrine pancreatic insufficiency (EPI) which results in fewer enzymes to digest protein; or chronic liver disease. Reduced levels also occur if protein is lost through kidney disease or hemorrhage. Burns and certain other skin diseases can cause loss of protein through the skin. Increased albumin is the spurious result of dehydration.

Total protein includes albumin, fibrinogen and globulins. Fibrinogen is involved in the formation of blood clots and levels increase in inflammation or neoplastic disease. It may also be increased mildly if the animal is dehydrated. It can be, but is not normally, measured separately as part of the profile. Globulins are larger proteins commonly referred to as antibodies. Often globulin is listed as total protein minus albumin, more accurate assays separate not only albumin from globulin but alpha, beta and gamma globulins from each other. Alpha globulins are acute reacting antibodies responding to tissue injury and inflammation, beta globulins are associated with acute liver disease, and gamma globulins are associated with chronic inflammatory diseases, immune mediated diseases and some lymph based cancers. Some reports will include the ratio of albumin to globulin.



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Alkaline phosphatase (ALP) is a group of enzymes that originates from every tissue in the body. High activities occur in liver, bone, intestine, kidney, placenta and white blood cells. Although not normally done, the enzymes from the various organs can be isolated and measured. In healthy animals most ALP is of liver origin. Increased ALP can indicate liver disease (due to interruption of bile flow), bone disease (osteosarcoma, bone healing or hyperparathyroidism) or increased blood cortisol either because corticosteroids have been given or due to Cushing's disease (hyperadrenocorticism). Other drugs especially phenobarbital can also increase ALP. In acute liver disease, ALP may remain normal while other liver enzymes rise, but ALP levels may continue to rise during recovery. In geriatric dogs certain malignant cancers (mammary, squamous cell carcinoma and hemangiosarcoma) may produce a very high ALP.

Alanine aminotransferase (ALT) {aka as glutamic pyruvic transaminase (SGPT)} is an enzyme considered liver specific in the dog. Liver damage – sublethal damage or necrosis - causes ALT to increase in the bloodstream. The level of increase reflects the number of cells that have been damaged. In acute disease a reduction in ALT is favorable, but in chronic cases may just reflect that most of the liver is already compromised. Elevation in ALT does not provide information as to whether the liver disease is reversible or not.

Aspartate aminotransferase (AST) {aka glutamic oxaloacetic transaminase (SGOT)} occurs in most cells but is considered diagnostic of liver and muscle disease. It is less specific and less sensitive to liver damage than ALT.

Other enzymes used to detect liver injury include gamma glutamyl transferase (GGT) and sorbitol dehydrogenase (SDH).

Bilirubin is produced by the liver, spleen and bone marrow as they recycle old red blood cells. Most bilirubin is conjugated in the plasma with proteins although some will be free. In the case of hemolytic anemia or internal hemorrhage most of the increase will be free bilirubin. Blockage of bile flow – either in the liver or gallbladder leads to an increase in conjugated bilirubin. Acute and chronic liver disease usually produces a combined response with increases in both types. Large amounts of bilirubin in the bloodstream will give a yellow color to the mucus membranes, inside the ears and eye whites. This is called icterus or jaundice. Bilirubin is further broken down and eliminated in both the urine and stool. In dogs increases in bilirubin in urine precedes that in the serum.

Bile acids Cholic acid and chenodeoxycholic acid are produced by the liver, combined with amino acids glycine and taurine and secreted into the bile to assist in fat digestion and absorption as well as absorption of the fat soluble vitamins. They are stored in the gall bladder. A bile acid test is used to evaluate the function of the liver and its blood flow to the liver, and to diagnose dogs with portosystemic, shunt, where blood from the intestines



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by-passes the liver and goes straight to the general circulation. The bile acid test measures a fasting blood sample and a blood sample two hours after eating. In normal dogs, bile acids released to digest a meal are recovered into the portal blood and returned to the liver. If the dog has a portosystemic shunt the bile acids enter the general circulation and will be dramatically elevated.

Blood Urea Nitrogen (BUN) Only small amounts of urea are ingested, most is made from ammonia - either from the break down of protein or absorbed from the large intestine - in the liver. Urea is excreted by the kidneys. Increased protein breakdown due to increased protein in the diet, hemorrhage, necrosis, starvation, prolonged exercise, infection, fever or corticosteroids causes a mild increase in BUN. Decreased perfusion of the kidneys caused by dehydration, shock or cardiovascular disease can also increase BUN. In dogs with kidney disease approximately 75% of the kidneys are nonfunctional before BUN will increase. BUN doubles approximately each time the remaining number of nephrons is halved.

Creatinine A small amount of creatinine may be ingested from diets rich in muscle meats. Most, however, comes from the conversion of energy stores of phosphocreatine in the muscles to creatinine - a waste product that is eliminated from the body by the kidneys. The creatinine pool is influenced by muscle mass, which in turn can be affected by muscle disease, wasting and training. Unlike BUN, creatinine is less influenced by diet or urine flow, and elevation of creatinine is the result of kidney disease or dehydration.

Amylase is an enzyme produced by the pancreas, small intestine and liver. Amylase helps the body break down sugars. In healthy animals serum amylase is non-pancreatic in origin. In pancreatitis (inflammation of the pancreas) or pancreatic cancer amylase can leak into the lymph system and from there to the blood. The higher the level (3 to 4 times normal) the more likely the source is the pancreas. Kidney disease and intestinal obstruction can also increase amylase; corticosteroids can increase it or decrease it. Occasionally, animals with pancreatitis can have normal serum levels of amylase. Because pancreatic disease isn't the only cause of increased amylase, levels are assessed in conjunction with those of lipase.

Lipase is another pancreatic enzyme which is responsible for the breakdown of fats. It takes longer to get a lipase measurement than that of amylase. A two-fold or greater increase in lipase indicates acute pancreatic disease, and it is almost never normal if the dog has pancreatitis. However, increase can occur in kidney or liver disease or with corticosteroids.

Creatine phosphokinase (CK, CPK) CK is an enzyme that helps store and release energy from muscle. In healthy dogs levels vary considerably with age, at one day old puppies have 5



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times the activity of adults. Adult levels are reached at 7 months of age. Old dogs may have lower levels. Levels may be artificially increased by hemolysis, excess bilirubin or muscle derived from difficult or repeated venipuncture. Elevation may indicate infection; myositis; trauma; degenerative, metabolic, ischemic or nutritional myopathy and involve heart muscle as well as skeletal muscle. The increase does not correlate to the extent of the damage. Even minor insignificant damage can cause elevation in CK. Two other enzymes - lactate dehydrogenase (LDH) and aspartate aminotransferase (AST, GOT) - may also be measured to determine muscle function. Results tend to mirror CK, but they are less sensitive.

Glucose is blood sugar. Its level is regulated by the pancreatic hormones insulin and glucagon. Insulin increases the uptake of glucose by liver, skeletal muscle and fat primarily, as well as uptake of some other simple sugars, amino acids, fatty acids, potassium and magnesium. Glucagon is released in response to low blood sugar and causes the liver to convert stored glycogen into glucose. Corticosteroids antagonize insulin's effects. Glucose is increased in dogs and cats with diabetes mellitus - lack of insulin. It may be mildly increased in dogs with Cushing's disease. (Glucose can temporarily increase in the blood if the dog is stressed by having blood drawn or the general examination. If glucose is also elevated in the urine, the blood glucose elevation is not transient.) Low blood sugar occurs less commonly and can be indicative of pancreatic cancer or overwhelming infection (sepsis) or administration of excessive insulin. It may also indicate improper handling of the sample. An animal with low blood sugar will be depressed, seizing or even in a coma.

Cholesterol There are four major fats in plasma; the two most often measured are cholesterol and triglycerides. They travel bound to peptides in complexes called lipoproteins. Cholesterol levels are usually inversely related to thyroid hormone activity, and it is one of the best indicators of thyroid disease. Liver disease, acute pancreatitis, diabetes mellitus, and kidney disease (nephritic syndrome) and corticosteroid drugs, but not Cushing's disease, can also elevate cholesterol. High cholesterol does not predispose dogs to cardiovascular disease.

Triglycerides must be measured in fasting samples. Elevation indicates endocrine (pancreatic, thyroid), liver, kidney or exocrine pancreatic disease.

The electrolytes usually measured include sodium (Na^+), potassium (K^+), chloride (Cl^-) and TCO_2 - which is primarily a measure of bicarbonate (HCO_3^-). The sum of positive ions minus the sum of negatively charged ions is called the anion gap, and is used to determine acid base abnormalities. It increases in such diseases as lactic acidosis, diabetes mellitus,



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ketosis, renal insufficiency and some toxicities like ethylene glycol (antifreeze) poisoning. A decrease is rare.

Sodium is essential for proper kidney function and water retention. The correct balance between sodium and potassium ions inside and outside nerve and muscle cells is essential for their proper function. Low blood sodium is most commonly seen with Addison's disease (hypoadrenocorticism), but can also be seen in diabetes mellitus or an animal that has been vomiting.

Potassium is increased in the dogs with Addison's disease, as well as with acute kidney failure, and in animals with a ruptured or obstructed bladder. Low potassium is associated with anorexia, vomiting, diarrhea, diabetes or the use of diuretics. Many profiles calculate sodium potassium ratios. If this number is less than 27 it indicates Addison's disease.

Chloride changes tend to parallel those of sodium, but loss of stomach hydrochloric acid can result in low chloride and normal sodium.

TCO₂ Loss of bicarbonate can occur through diarrhea. Loss can also be relative to a build up of lactic acid, ketones, or uremic acids in kidney failure. Some organic poisons may also lower blood acidity. In cases of loss of stomach acid, the kidneys may excrete more bicarbonate to compensate.

Calcium The levels of calcium potassium and magnesium are regulated by parathyroid hormone, calcitonin from the thyroid and Vitamin D. Serum calcium is a reflection of relative bone formation and resorption. It is rarely affected by dietary intake. High blood calcium is most commonly associated with cancer. Less common causes of elevated calcium are chronic kidney failure, primary hyperparathyroidism, poisoning with certain types of rodent bait and bone disease. Low blood calcium may occur in bitches shortly before giving birth or during the early nursing period. This is called eclampsia. It causes tetany, the muscles become rigid. Hypofunction of the parathyroid will also result in low blood calcium. Dogs poisoned with antifreeze may have very low blood calcium.

Phosphorus Levels will be higher in young animals than in adults. Serum phosphorus is largely regulated by the kidneys, although parathyroid hormone can increase resorption. Dietary intake can directly affect serum levels. Phosphorus increases in chronic kidney disease, as with BUN and creatinine, phosphorus increases in these patients when about 75 percent of both kidneys is damaged.

Blood serum as well as urine components can vary markedly throughout the day. Taking blood from a fasted dog will minimize those variations, but fail to show nutrient sensitive diseases. Blood glucose will be low, as will insulin, while glucagon secretion will be elevated. In anorexic patients, or those fasted more than 24 hours, fat will start to break



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down excessively to provide energy and increase levels of ketones which might make the blood more acid. In a dog that has been eating, elevated ketones would suggest it had diabetes or liver disease, however. BUN and phosphorus decrease in anorexic patients, so that renal failure might be missed. Fortunately creatinine levels will not be affected. Fasting for 24 hours increases the resorption of sodium and excretion of potassium by the kidney. More calcium, magnesium, uric acid and ammonia will also be excreted. In general, fasting 6 to 12 hours before a blood draw is optimal. If lipemia persists after fasting for 24 hours it indicates problems with fat metabolism. If the purpose of the blood test is to evaluate the effect of dietary modification on a disease process, blood should be drawn 2 to 6 hours after food consumption. If you are reevaluating the thyroid levels of a dog already receiving supplementation, blood should be drawn 4 to 6 hours after the morning pill. At this point thyroid levels will be maximal, and should be in the upper 50% of lab normal to 150% of the upper limit.

I have not described urinalysis here. However, to fully evaluate the health of a dog I would recommend performing one as part of the wellness check-up. Urine can be obtained by catching a sample during normal urination, by passing a catheter into the bladder or by placing a small needle through the body wall into the bladder, a procedure called cystocentesis. Depending upon why the urine sample is being collected, one collection method may be preferred over another.

I hope that this presentation will assist you in understanding the results of your dog's blood test. It is by no means meant to replace the services of your veterinarian in treating your dog.

Linda Aronson, DVM.