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A Beginner's Guide to the Interpretation of Laboratory Tests

It is a rare day that I do not suggest, "blood work" of some sort for a patient. While the history and physical examination of a patient are still the cornerstones of diagnosis, most veterinarians rely more and more on a huge variety of tests and techniques that allow us to look "beneath the fur" to better understand our patient's problems. Because blood testing is safe, readily available, relatively non-invasive, and generally very cost-effective, it is the most frequently used tool in evaluating the sick and the healthy pet. Nowadays, veterinarians can get results for most common blood tests immediately in-house, or overnight, using one of the many specialized veterinary labs that service our profession.

Looking at the requisition form for the lab that our practice uses in addition to our in-house diagnostics, I count approximately 100 different blood tests, that I can request, either singly, or in bundles of related tests, called "profiles". Many of the available offerings are for very specialized cases, and would not be in daily use (i.e. I wouldn't ask for progesterone testing on a male dog who was vomiting). In this article, 1 want to discuss the common serum chemistry tests; what they are and why we do them.

Blood 101
Blood is composed of three basic components; red blood cells, white blood cells and platelets, and serum. The serum is the stuff that is left over after the blood has clotted and the cells have been removed using a centrifuge. Serum accounts for roughly 60% of the total blood volume, and contains most of the interesting stuff.

Left untreated, whole blood will clot due to the action of the "clotting cascade", activated by exposure to foreign substances, such as air, the barrel of the syringe, or the inside of the blood tube. If clotting is prevented by the addition of an anticoagulant, and the cells removed, the resulting liquid is called plasma. The main difference between serum and plasma is the presence or absence of the main clot protein, fibrin. Most analyses require serum rather than plasma. There are a number of different blood tubes available, usually with colour-coded tops, that contain different anticoagulants or no anticoagulants at all, to allow for correct sample preparation. Serum and plasma can both be frozen for later analysis, but blood cells cannot.

Normal, healthy serum or plasma is clear or a very pale peach colour. Serum or plasma that is milky, red or yellow can be a sign of disease or poor sampling technique, and can interfere with accurate interpretation of results. Serum can look milky due to the presence of large amounts of transit fat in the blood; this can occur if the sample was drawn right after a meal, or in some disease states such as pancreatitis. Red serum usually results from a traumatic blood drawing. Too much suction on the needle can rupture red blood cells; this is called haemolysis. Yellow, or icteric, serum may indicate liver disease or the abnormal destruction of red blood cells (haemolytic anaemia).

Any planned blood testing is usually best done with the animal fasted, using the biggest blood vessel the vet or technician can hit. With the biggest needle, the animal can tolerate! I like the Vacutainer system; special needles and holders that allow blood to be drawn directly from the blood vessel into a sample tube that has a vacuum. Whether a test protocol requires serum or plasma, the blood should be "separated" as soon as possible, as the continued presence of cells may affect the results. This is particularly true of glucose levels, as red cells use glucose for energy, and blood that is not quickly separated may show a false reduction in the glucose reading.

The Shopping List; commonly available blood tests....

It would be silly to test every patient for everything; too expensive, and not enough blood in the teeny dogs and cats! It is generally best to choose specific tests based on a presumptive diagnosis, rather than go on a fishing expedition, hoping to find something. There are times, however, where the fishing expedition is the best choice, such as the well pet check up, where no problems are expected, and one wants a comprehensive overview of organ function. Also, in the very sick animal, where a lot of information is needed in a hurry, a number of tests might be ordered at once. Most labs

will offer "Profiles" or "bundles"; a group of tests that you can order quickly, and get a good price on. I will talk about some of the common profiles a little later in this article.

When the lab report comes back, the results of each test are reported as a number, the unit that number is in (there are several systems in use world wide), the reference range for that test, adjusted for species and age (the range of values that includes 95% of the normal population), and often a “Flag" (star or arrows) that quickly tell you if result is outside the reference range: For example G LU 19.3 mmol/L (3.0 7.9 mmol/L) ****HI

In this case, the reading for glucose was 19.3 "units", well above the reference range, and I would worry that this dog is diabetic. One must be careful not to pay too much attention to the flags, as results barely outside the reference range may be normal for that patient.

The most commonly requested tests in my practice include the following, presented in alphabetical order for convenience. Normal values and reference ranges are not included, as these will vary from lab to lab.

Albumin (ALB)
Albumin is a low molecular weight protein produced by the liver. Albumin is the main transport form of protein in the body, and is largely responsible for keeping fluid inside blood vessels. Albumin will bind to many drugs and carry them through the blood stream. ALB levels are reduced in starvation, some liver disease, some kidney disease, and some GI mal-absorption syndromes. ALB levels may be elevated in dehydrated patients.

Alanine Aminotransferase (ALT or SGPT)
Alanine aminotransferase is a protein making enzyme produced almost exclusively inside liver cells. ALT is released into the blood stream as liver cells die. ALT levels may be extremely high in acute liver disease, and nearly normal in chronic liver problems. As with many blood tests, trends over time in ALT levels give the most information. Low ALT levels are not significant. A related enzyme, aspartate aminotransferase (AST or SGOT) may also be evaluated. It is less liver-specific (also found in muscles), and has a shorter half-life in the serum than ALT.

Alkaline Phosphatase (AP)
Alkaline phosphatase is produced by many tissues in the body. The most common causes for an elevation in AP are liver disease, bone disease or excess cortisol (from drug therapy, or hyperadrenocorticism). Young animals have high levels of AP. Low levels of AP are not considered a problem.

Amylase (AMY)
Amylase is an enzyme that may originate from the pancreas, liver or small intestine. Amylase helps in the breakdown of sugars. In healthy dogs, most AMY comes from the small intestine. AMY may be elevated in acute pancreatitis, or as a result of corticosteroid administration. Low levels of AMY are not significant.

Bile Acids
Bile acids are synthesised in the liver from cholesterol and excreted into the bile as bile salts, after conjugation with various amino acids. Some of the bile salts are absorbed in the intestine and "recycled" by the liver. Elevations in bile acids, especially after meals, are indicative of defects in hepatic blood flow (either portosystemic shunt, or hepatic microvacular dyspiasia. HMD), or reduced functional hepatic mass.

Bilirubin (BIL)
Bilirubin is a product of the metabolism of "old" red blood cells; it is produced by the liver cells, and excreted into the G1 tract as bile. Bilirubin levels will be elevated in biliary obstructive disease, and will cause a visible jaundice above a certain level. Bilirubin may also be increased in hemolytic disease, where the large amount of red blood cell breakdown products overwhelms the liver’s ability to process and excrete it through the normal pathways.

Blood Urea Nitrogen (BUN, UREA)
>Blood urea nitrogen is a waste product of protein metabolism that is made by the liver, and excreted in the urine. A low BUN may indicate starvation, liver insufficiency or over-hydration, and may be normal in late pregnancy. elevated BUN usually signals kidney disease, but can also be caused by dehydration, shock, hypoadrenocorticism, bladder rupture and a high protein diet. In kidney disease, elevations in BUN will only be noted when more then 75% of kidney function is gone. Generally, the higher the BUN, the greater the renal insufficiency.

Calcium (Ca)
Calcium is an essential mineral for the smooth functioning of many body systems. These include the skeleton, muscles, nerves, and many enzyme reactions. Half the calcium in the blood is bound to protein. Because of the importance of Ca, the levels are tightly regulated, and the normal reference range quite small. High Ca levels are usually associated with cancer (especially lymphosarcoma), chronic renal failure, an over functioning parathyroid gland, and some rodenticides. Low calcium levels may be seen with eclampsia, antifreeze poisoning, and malabsorbtion from the gut.

Cholesterol (CHL)
Cholesterol is a form of fat that is both found in the diet and synthesised in the liver. Cholesterol is an important precursor of many hormones. Elevated CHL may be seen in many endochnopathies (e.g. hypothyroidism). High CHL does not appear to predispose dogs or cats to heart problems as it does in people.

Creatinine (CRE)
Creatinine is produced at a fairly steady rate by muscle tissue, and is excreted unchanged by the kidneys. CRE is elevated in most of the same situations where BUN is high. CRE may also be increased by severe muscular exertion. CRE is not affected by diet or liver function to the extent that BUN is, and is therefore more kidney specific.

Glucose (GLU)
Glucose is the main energy source of the body, and is regulated by the pancreatic hormones insulin and glucagon. GLU levels are elevated by diabetes mellitus, pancreatitis, steroid therapy, hyperadrenocorticism, and transiently after eating. Low blood sugar is associated with hepatic insufficiency, insulin secreting tumours, insulin overdose, hypoadrenocorticism and starvation (especially puppies). GLU may be falsely reduced if the bicod sample was allowed to sit for too long before processing.

Lipase (LIP)
Lipase is a fat metabolising enzyme that is quite specific to pancreatic tissue. Elevations in LIP are associated with pancreatitis, some liver disease. and steroid therapy. low levels of LIP are not significant.

Phosphorous (PHOS)
Phosphorous levels are primarily regulated by the kidney. through the influence of the parathyroid gland. Dietary intake can also affect PHOS levels (diets high in animal protein are generally high in PHOS). PHOS levels may be falsely elevated in hemolysed blood samples. PHOS levels are higher in young animals, due to more active bone metabolism. P1108 levels are most commonly elevated in renal disease, and less often in parathyroid hormone imbalances. Any condition that causes an alteration in Ca may affect PHOS, as these two minerals are tightly co-regulated.

Potassium (K)
Potassium is approximately 97% intracellular and 3% extra cellular, so serum K values do not always accurately reflect whole body K. Both high and low levels of K can cause heart problems. Low K levels can also be associated with muscle weakness. High K levels are found in hypoadrenocorticism, urethral obstruction and oliguric (law urine output) renal failure. Low K levels are associated with diuretic therapy, many causes of increased urine output (including chronic renal failure), vomiting and diarrhea, and anorexia.

Sodium (Na)
Sodium is the "other half' of K; most is extra cellular. Sodium levels are largely controlled by the kidneys. High Na levels may reflect dehydration (usually increased urine loss without replacement), increased intake or corticosteroid use. Low Na is most commonly seen with hypoadrenocorticism.

Total Protein (TP)
Total protein is the sum of ALB (see above) plus the large molecular weight proteins called globulins, Most globulins are immune system products, and are elevated in many cases of infection, inflammation and cancer. TP may also be elevated in dehydrated patients. A related test, called TOTAL SOLIDS, is usually performed on plasma and includes the protein fibrinogen (inactive fibrin).

Putting it all together; the profiles.
Once I have completed my initial examination of a patient and taken a good history, I will have some idea of the likely "rule-outs" that best explain the clinical picture I am seeing. If blood work or other testing is indicated, I need to be sure to order the right tests to answer the questions posed by my exam and history findings. For example, a dog with a history of weight loss and increased thirst might well be diabetic and have an elevated GLU, but it could also have kidney failure, so it makes sense to answer both those questions at once.

There are very few occasions where a single test will tell the whole story. Even when a single test is markedly abnormal, such as the elevated GLU example I used above, there are usually other aspects of the suspected disease process that need to be investigated; i.e. does the dog with the elevated GLU also have pancreatitis or liver disease?

Most of the time, laboratory evaluations of health and disease will involve multiple tests to fully characterise the patient's condition. Below are some of the "profiles" that I use in dealing with my canine patients. In practice, I would most likely also be doing a complete blood count as well.

1. **Pre Anesthetic or Well Pet Profile** - ALT, BUN, CR, GLU, TP
2. **Geriatric Well Pet Profile** - add AP, Ca, CHOL, possibly thyroid evaluation.
3. **Liver Function Profile** - ALB, AP, ALT, AST, BIL, Bile acids, TP
4. **Renal Function Profile** - ALB, BUN, CR, PHOS,
5. **Ain't Doing Right" Profile** - AP, ALT, AMY, BUN, CA, CR, GLU, PHOS, TP
6. **"Really Ain't Doing Right" Profile** - add ALB, K, Na, (chloride), LIP
7. **Electrolyte Profile** - Na. K, (chloride), PHOS, Ca

In most cases, I would be repeating blood work at regular intervals to monitor the progress of the case, and to follow up new leads. Additional evaluations, such as for thyroid and adrenal dysfunction, or pancreatic insufficiency, require specialised protocols, and would not be in routine use, unless the index of suspicion for those diseases was high. Well-timed and well-selected blood tests can add enormously to our success in treating many small animal conditions. I can't tell you how satisfying it is to have a hunch confirmed, and a clear idea of the best course of treatment, all from a bit of blood. Sometimes, though, 1 have to remind myself not to get too upset if all the lab work comes back normal; that is, after all, a "good thing"!

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