Cheap, Easy Blood Tests for the Emergency Patient

David Liss, BA, RVT, VTS (ECC, SAIM), CVPM

Introduction

There are many cheap and easy blood tests to run in the veterinary ER that can yield a large amount of emergency information. A patient will not usually die of an extremely high ALT value, but could certainly die of anemia or hyperkalemia. These tests identify life-threatening abnormalities quickly and easily and can greatly enhance care of the veterinary emergency critical care patient. Tests covered in this lecture include: PCV, TS, Buffy coat, Blood Glucose, BUN/USG, lactate, Electrolytes, and a blood smear.

PCV/TS/Buffy Coat

The Packed Cell Volume represents the volume of red blood cells in a column of serum from 0-100%. This measurement can indicate many things about the hemodynamic/fluid balance status of the patient. A low PCV indicates anemia, or absolute/relative lack of red blood cells, and a high PCV can indicate hemoconcentration, dehydration, polycythemia, and hyperviscous blood. A PCV value should be approximately 35%-40% depending on reference range or reference text. A PCV >45% typically indicates hemoconcentration/dehydration/ hypovolemia and/or polycythemia. A PCV <35% indicates anemia. The PCV tends to be interpreted as a relative number, with no absolute reference. A PCV of 47% may be perfectly appropriate in a patient or it might indicate anemia and hemoconcentration and after IV fluid therapy will drop to <30%. Typically the PCV and TS are measured together to fully assess the protein influence on the presence or absence of hemoconcentration or hypo/hyper proteinemia. There are typically 6 categories: Low PCV/Normal TS, High PCV/Normal TS, Normal PCV/Low TS, Normal PCV/High TS, High PCV/High TS, Low PCV/Low TS.

The total solids represents a measurement of all large molecules in the serum contributing to oncotic pressure. These are typically proteins and so the measurement is often called the total protein. Proteins in serum include globulins, albumin, fibrinogen and others. Albumin and globulin have the largest contribution to the TP and so hypoalbuminemia, hyperalbuminemia, hypoglobulinemia and hyperglobulinemia are typically expressed as a low or high TS respectively.

> **Low PCV/Normal TS (PCV <30%, TS = 7) g/dL or 70 g/L):** IMHA, non-regen anemias (aplastic, PRCA, chronic disease)
> **High PCV/Normal TS (PCV >60%, TS = 7 g/dL or 70 g/L):** Polycythemia, Endocrine diseases, HGE. HGE is an important rule/out as IV fluids will unmask the hypoproteinemia through hemodilution.
> **Normal PCV/Low TS (PCV = 40%, TS <5 or 50):** Protein-losing disease, liver failure, hemorrhage
> **Normal PCV/High TS (PCV = 40%, TS >9 or 90):** FIP, Multiple myeloma, severe dehydration with anemia
> **High PCV/High TS (PCV > 60%, TS > 8-9 or 80-90):** Hemoconcentration
> **Low PCV/Low TS (PCV <30% and TS <5 or 50):** Hemorrhage, Chronic blood loss (GI bleed)

Additionally, the PCV tube can yield important other information including: serum color and buffy coat. Serum colors are summarized below:

> **Red**: Hemolysis (presence of free hemoglobin in serum)
> **Yellow:** Icterus (presence of bilirubin in serum)
> **Milky/White**: Lipemia (increased triglycerides in blood)

Buffy coat is a fairly inaccurate estimate of the WBC count. A normal buffy coat should be <1-2% and higher values can indicate a leukocytosis.

Blood Glucose

Blood glucose is maintained in normal healthy animals through the production, storage and release of this simple carbohydrate in physiologic processes. Glucose is produced through the digestion of carbohydrates, or through the breakdown of stored glycogen (glycogenolysis), or produced through other substrates (gluconeogenesis). Through these processes blood glucose levels fluctuate to only minimal levels throughout the day. This also allows for short periods of starvation to occur. During hypoglycemia, hormones including cortisol, glucagon and epinephrine are released. These hormones raise the BG through inhibiting insulin secretion, enhancing gluconeogenesis and glycogenolysis, and by causing peripheral resistance to insulin, thereby raising the plasma BG level. During hyperglycemia, insulin is released from B-cells in the pancreas and causes glucose transport proteins in cells to facilitate the transport of glucose intracellularly. Insulin also inhibits gluconeogenesis and glycogenolysis.

Normal BG levels in dogs and cats are not the same. Dogs can have a resting BG level of 53-117 mg/dL (2.9-6.5 mmol/L) and cats can fluctuate from 57-131 mg/dL (3.1 to 7.2 mmol/L). Hypoglycemia occurs with a BG of typically <50 mg/dL (<2.7 mmol/L) although a more rapid drop in glucose can occur and therefore a higher BG than 50/2.7 could show signs of hypoglycemia. This may occur due to decreased production or increased utilization of glucose. Typical causes include puppy hypoglycemia, insulinoma, iatrogenic insulin OD, xylitol toxicity, sepsis and fulminant hepatic failure. Hyperglycemia typically occurs with a BG of greater than 117/6.5 in the dog and 130/7.2 in the cat although cats can have a significant stress hyperglycemia. Hyperglycemia typically occurs in the absence of insulin or the presence of insulin resistance. The most common causes are diabetes mellitus or stress, although it can occur in pancreatitis, Cushing's disease, steroid administration and iatrogenic causes like administration of dextrose bolus/IV fluids.

Measurement of blood glucose is typically easy in the veterinary hospital. BG can be measured with arterial, venous or capillary blood and can also be measured from plasma/serum OR whole blood. Plasma/serum measurements are higher than whole blood as the water content is higher. As glucose can freely diffuse across RBC membranes the glucose will typically be hidden in the RBC in a whole blood measurement. Venous samples will most likely be slightly lower than capillary samples but in patients who have fasted all sample types (venous, arterial, capillary [ear in cats]) are basically the same.

Blood glucose can be measured most commonly via in-house analyzers and point-of-care analyzers/portable glucose monitors. Since portable/point of care instruments are readily available these are typically used in the emergency setting. These analyzers do not provide numbers that are identical to in-house analyzers but they are considered close enough to be clinically useful.

Blood Urea Nitrogen (BUN)/USG

Urea (or urea nitrogen) is a waste product of hepatic metabolism. Because it is a waste product and is kept in relatively low blood concentrations and is filtered by the glomerulus elevated BUN indicates an issue with glomerular filtration rate (GFR) and is termed azotemia. There are three kinds of azotemia- pre-renal, renal, and post-renal. Pre-renal azotemia refers to decreased renal blood flow which lowers the GFR typically caused by hypovolemia/dehydration, renal azotemia is typically caused by renal disease/failure, and post-renal azotemia is caused by ureter/urinary obstruction. A urine specific gravity (if obtainable) aids in the support of categorizing the azotemia.

BUN	USG	Azotemia
High	Concentrated	Pre-renal
High	Isosthenuric	Renal
High	Concentrated	Post-renal

A BUN can be easily estimated from an AZOstick which gives a range of BUN either 35-50 or 50-80 mg/dL. An elevation of BUN can indicate hypovolemia/dehydration or possible acute kidney injury and is a valuable test in the emergency setting.

Lactate
Lactate production is the result of anaerobic cellular metabolism. It is a bypdroduct of metabolizing pyruvate to produce ATP for cellular energy. Glycolysis produces pyruvate in the cytoplasm of cells. Under aerobic conditions pyruvate traverses into the mitochondria and produces lots of ATP via the Kreb's cycle. Red blood cells do not have mitochondria, so lactate dehydrogenase converts pyruvate to lactate to produce ATP. The excess lactate diffuses out of the cell and back to the liver to assist in making glucose via gluconeogenesis. This is called the Cori cycle.

In states of cellular hypoxia, only glycolysis occurs, producing pyruvate. Because pyruvate cannot travel into the mitochondria, LDH converts pyruvate to lactate and produces a small amount of ATP. As more and more lactate accumulates, it cross into the intravascular space and travels around the body. If global hypoxia is present, other tissues will be unable to utilize lactate to make glucose and it accumulates in the intravascular space. Lactate is dissociated with a Hydrogen ion at physiologic pH. Thus the excess hydrogen lower blood pH. Lactate is metabolized by the liver, and excreted by the kidneys.

There are two types of Lactic Acidosis. Type A, where tissue hypoxia is present with normal mitochondrial function and Type B, where oxygen delivery is adequate, but carbohydrate metabolism/mitochondrial dysfunction are present. Type A lactic acidosis indicates decreased DO_2 (oxygen delivery to tissues) through either, a decreased cardiac output, hypovolemia, or decreased oxygen content (as in anemia) or a decreased ability to extract O_2 (edematous states). Type B lactic acidosis has 3 subtypes. Type B-1 comes from decreased clearance of lactate. This may occur with liver failure, diabetes (from abnormal carbohydrate metabolism), renal failure, or in neoplasia. Type B-2 lactic acidosis occurs with drugs/toxins that affect a portion of glycolysis called oxidative phosphorylation. These include ethylene glycol, carbon monoxide, salicylates and acetaminophen. Type B-3 lactic acidosis occurs with mitochondrial diseases.

Lactate is typically measured to indicate cellular hypoxia as a result of decreased oxygen delivery (shock). Typically a lactate of greater than 2.5-3 mmol/L indicates this condition. Lactate can be easily measured on point-of-care devices or portable lactate meters.

Electrolytes
Sodium, Potassium, and Chloride can be easily run on in-house lab analyzers and can provide a wealth of information. While chloride is an important electrolyte to consider, abnormalities of sodium and potassium will be discussed in this manuscript.

Sodium is the most abundant cation and represents a large portion of positively charged ions in the extracellular fluid. Sodium is typically thought to indicate fluid and water balance in the body, with elevations in sodium (hypernatremia) representing a deficit in free water, and decreases in sodium (hyponatremia) indicating elevations in body water. Although this is not always true, a simplified discussion of this electrolyte is covered in this lecture. Hypernatremia is a "water" problem, not necessarily an excess sodium condition. Typical causes include: dehydration/hypovolemia, lack of intake of water, sodium toxicity (rarely), diabetes insipidus. Rapidly correcting hypernatremia that has a chronic nature can lead to cerebral edema and brain injury. Hyponatremia is not common and has several causes including: pseudohyponatremia (hyperglycemia), SIADH, liver failure. Hypo and hypernatremia can be life-threatening if severe enough.

Potassium, in contrast to sodium, is the most abundant intracellular cation and has very low serum concentrations. However, since it is important in muscle contraction (cardiac and smooth) hypo or hyperkalemia can be life-threatening and produce cardiac arrhythmias or hypoventilation due to intercostal/diaphragm muscle paralysis. Hyperkalemia causes include: acute kidney injury, ureteral or urethral obstruction, Addison's disease, or massive hemolysis/rhabdomyolysis. Hypokalemia causes include: urinary loss (DKA, renal failure), B-agonist overdose, diuresis and use of medications (furosemide).

Blood Smear
Preparation and reading of a blood smear is an extremely inexpensive and highly valuable test in the veterinary ER. A smear can quickly evaluate red blood cells, white blood cells, platelets, amongst other abnormalities and aid in, or even actually diagnose a patient's condition. Technicians should be proficient at reading blood smears.

A blood smear can be rapidly prepared using EDTA blood and placing one drop of blood on the end of a clean glass slide. The spreader slide should be applied and a nice even smear made with a visible "fingerprint" appearing feathered edge. The slide should then be stained as per hospital policy.

Evaluation of the smear starts on the 10x objective (lower power) and should evaluate the feathered edge for general cell distribution, presence of platelet clumps, microfilaria etc. RBCs can be evaluated for general density and rouleaux/agglutination patterns identified. WBC numbers can also be estimated. Once this initial scan is complete the objective should be enhanced to higher power while focusing in on the monolayer, which is just slightly away from the feathered edge.

A differential can be performed and various cells can be evaluated. Neutrophils should be evaluated for cytoplasmic appearance, toxic change, evidence of increased immature band neutrophils, and the other leukocytes evaluated as well.

Red blood cells can be evaluated for their color strength (poly or hypochromasia), shape (discoid or spherical), evidence of fragmentation like schistocytes, evidence of Heinz bodies, echinocytosis (indicating envenomation), and spherocytes which can rapidly diagnosis an immune mediated process. Also RBC inclusions like parasites can be identified.

Platelet counts can be estimated as well and platelet clumping identified. Macroplatelets can indicate regeneration in thrombocytopenic animals and a low platelet count can rapidly identify thrombocytopenia.

Conclusion
There are many cheap and easy tests to perform in the emergency patient which can yield a ton of information. All of these tests can be performed by just about any veterinary facility and can be rapidly performed by and interpreted by a veterinary technician. Employing these tests in your practice will enhance the quality of emergency care provided to your patients, as well as amplify the amount of data the veterinarian gets to diagnose the condition.