



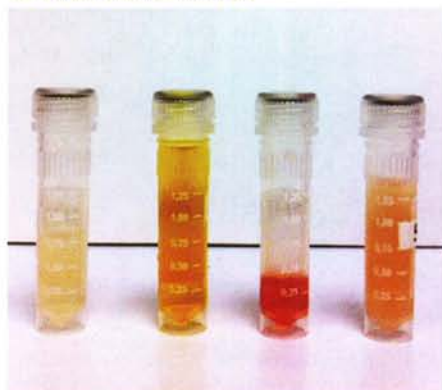
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Figure 1: Variations in serum quality (from left): lipaemic, icteric and two examples of haemolysis



# The practice laboratory – Part 2: biochemistry

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**ABSTRACT:** Part 2 of this series of articles is to help student nurses understand the biochemical tests they perform on a daily basis. It aims to match each test with the organ with which it most commonly associated, as well as common ailments diagnosed with each analyte.

In the first part of this series, the author introduced the analysers that are commonly found in the practice laboratory. This article will cover the common tests performed on a daily basis in most practice laboratories.

## Sample collection

Once a blood sample has been obtained from a patient, it is normally placed into either a serum (plain), serum gel, OXF (yellow-topped – oxalate fluoride) tube or an EDTA (pink, red and sometimes purple-topped) tube or 'vacutainer'. To perform serum biochemistry, use the serum or serum gel tubes; and for any haematology analysis, use the EDTA sample.

The OXF tube is normally only used to measure glucose and cannot be used to perform any other routine biochemical tests. Other blood tubes are available – such as citrate (green-topped) which is normally used for clotting factor tests, and lithium heparin which can also be used for biochemistry testing.

An important thing to note is the quality of the serum at the time of testing, because it can have a significant effect on the accuracy of the results (Figure 1). Serum quality can be broken down into four categories:

- normal – the serum is clear to straw-coloured
- lipaemic – the increase of turbidity (milky appearance) of the serum in a fresh sample (lipaemia) is caused by the presence of fat (triglycerides and cholesterol) and is often seen when blood samples are taken from patients that haven't been starved. Lipaemia can interfere with many test results.
- haemolysis – is when the serum goes a pink to red colour. Haemolysis is caused by the loss of haemoglobin from red blood cells following cell

damage. Common causes include trauma during sample handling, freezing, too much suction during sampling, and shaking the blood tube. Haemolysis can also be caused by some medical conditions. Severe haemolysis will also interfere with many test results.

- icteric serum – the serum is various shades of yellow. It is caused by the build-up of bilirubin in the serum and can be seen in conditions such as liver disease and auto-immune haemolytic anaemia.

## Serum biochemistry

Biochemistry is probably the most common test performed by veterinary nurses in the practice laboratory. In this section of the article, the author provides a list of the common tests performed and the organ function with which they are associated. Reference ranges are not described here, because they all vary depending on the technique and method used by the analyser.

### Liver

- **ALT** (Alanine aminotransferase) is almost completely liver specific in dogs and cats. ALT is found in the cytoplasm of hepatocytes that make up the liver and an elevation in ALT is caused by hepatocellular damage.

Conditions that cause ALT elevations include hepatitis, tumours, hyperthyroidism (in cats) and trauma. It is worth noting that ALT is not an indicator of liver function.

- **ALKP** (Alkaline phosphatase) is present in a wide range of body tissues and elevations are mainly the result of the release of ALKP from the liver and bile ducts, and from bone growth in young animals.

Conditions that can cause elevations in ALKP include liver disease, Cushing's disease, steroid therapy and anti-epileptic drug therapy. Decreases in ALKP are not thought to be of clinical significance.

- **Bilirubin** is a yellow pigment which is mainly produced in the liver from the breakdown of red blood cells. It can either be recycled through the gut and liver, or passed out of the body in faeces. The kidneys also excrete a small amount of bilirubin. It is the build up of bilirubin that causes jaundice of the skin and mucous membranes.

Increased bilirubin levels can be caused by an increased rate of breakdown of red blood cells (haemolysis, haemorrhage), hepatocellular damage and obstruction of the flow of bile.

- **Bile acids** are a measure of the function of the liver. Although a resting bile acid measurement is part of a full blood profile, normally a bile acid stimulation test is performed. Bile acids are synthesised in the liver and act as emulsifying agents during fat digestion. Bile acids are normally recycled through the gut and liver and levels will increase slightly after a meal.

Increased bile acid levels can be caused by impaired liver function, biliary obstruction or a porto-systemic shunt in young animals. Decreased serum bile acid levels can be caused by an intestinal obstruction or malabsorption.

## Pancreas

- **Amylase** is a digestive enzyme which mainly comes from the pancreas, liver and small intestine. Although serum amylase is derived principally from the pancreas, it is not a specific marker for pancreatic disorders; although acute pancreatic inflammation will cause a marked elevation of serum amylase.

Conditions that can cause elevations in serum amylase include pancreatitis and renal disease.

- **Lipase** is a digestive enzyme primarily found in the pancreas. Levels of lipase are elevated in pancreatitis. It is worth noting that levels of amylase and lipase can vary markedly over a few days.

“An important thing to note is the quality of the serum at the time of testing, because it can have a significant effect on the accuracy of the results.”

Grossly haemolysed and lipaemic samples will artificially lower or elevate amylase and lipase levels.

## Kidneys

- **Urea** is formed in the liver from the breakdown of ammonia, and is excreted through the kidneys in urine. Common elevations in urea can be classified into three categories:

1. pre-renal – causes include tissue necrosis, fever, infection, steroid therapy, dehydration and intestinal bleeding
2. renal – increased values are seen when 75 per cent of the nephrons become non-functional
3. post-renal – in patients where there is an issue with the flow of urine, such as cats with blocked bladders.

It is important that elevations in urea are interpreted alongside the clinical signs in order to identify the cause of the abnormality.

- **Creatinine** mostly originates from the patient's muscles as a consequence of the degradation of creatine. The kidneys filter creatinine from the blood and use it to concentrate urine before excreting it in urine. Well-muscled dogs, such as Labrador retrievers, may have slightly higher serum creatinine levels compared to other breeds, and this is considered normal. Other causes of elevated creatinine levels include renal disease and dehydration.

An increase in both urea and creatinine is classed as azotaemia.

## Serum proteins

Broadly speaking, serum proteins are made up of albumin and globulins – and together they appear on a profile as total protein. Almost all proteins are produced in the liver; except for immunoglobulins, which are produced by lymphoid tissue.

Albumin makes up the largest portion of the serum proteins. It serves as an osmotic regulator and carries bound substances, such as calcium. The globulins are associated with the inflammatory response.

Low total protein levels (hypoproteinaemia) can be associated with a decrease in protein synthesis (starvation, malabsorption, liver disease and congestive heart failure). Elevated total protein levels (hyperproteinaemia) can commonly be caused by dehydration and increased globulin levels. It is again worth noting that lipaemia will artificially elevate the total protein level.

Increased albumin levels (hyperalbuminaemia) can be caused by dehydration. This increase is relative and is caused by the reduced water content in the blood. Decreased albumin levels (hypoalbuminaemia) are caused by:

- decreased protein synthesis (starvation, malabsorption, liver disease and congestive heart failure)
- increased protein loss (burns, haemorrhage, sepsis or a protein-losing enteropathy).
- EPI (exocrine pancreatic insufficiency).

Globulin elevations are normally associated with inflammation and infections. Elevations may also be seen in cats with FIP and other conditions, such as liver disease and tumours.

## Electrolytes

- **Calcium (Ca)** is one of the most important ions in the body. It is used in bone and structural organisation, enzyme function, blood coagulation and the maintenance of fluid balances. It is also essential in muscle activity and is regulated by parathyroid hormone and vitamin D.

Common causes of low calcium levels (hypocalcaemia) include hypoalbuminaemia, pancreatitis and EDTA contamination.

Common causes of high calcium levels (hypercalcaemia) include tumours such as lymphoma, renal disease and lipaemic samples. High calcium levels are also seen in young animals as a consequence of bone growth.

- **Sodium (Na), Potassium (K) and Chloride (Cl)** are the most common electrolytes for which tests are run in the practice laboratory. Electrolytes ■

are very important for cell, muscle and nerve function. Chloride is also very important in the breakdown and digestion of food.

Levels of these electrolytes can fluctuate for many reasons, including renal dysfunction, Addison's disease, liver disease, vomiting and diarrhoea, to name but a few. To go into greater detail about the causes of high and low electrolyte levels is beyond the scope of this article.

### Cholesterol

Serum cholesterol merits its own section as it is very useful in the diagnosis of several metabolic disorders; although it is not itself diagnostic for any single disorder.

Causes of elevated serum cholesterol include hypothyroidism, Cushing's syndrome (hyperadrenocorticism), liver disease and pancreatitis.

Common causes of low serum cholesterol include advanced liver disease and malabsorption.

### Glucose

Glucose is probably the most commonly tested analyte in the veterinary laboratory. Blood glucose is an important source of energy for most body cells. It is normally obtained from the diet and the breakdown of carbohydrates.

The level of glucose is controlled mainly by two pancreatic hormones – insulin and glucagon. Insulin is secreted from the beta cells of the Islets of Langerhans in the pancreas when blood glucose levels are high, and stimulates the synthesis of glycogen from glucose which is then stored in the liver. Alpha cells secrete glucagon when sugar levels are low which stimulates the conversion of glycogen back into glucose.

Elevated glucose levels (hyperglycaemia) can be seen in conditions such as diabetes mellitus, pancreatitis, during steroid therapy or stress.

Low glucose levels (hypoglycaemia) are seen in conditions such as malabsorption, insulinomas and liver disorders.

### Summary

This is a basic guide to biochemistry and to give more detail would take more than one article. The author hopes it will enhance your understanding as to why the different tests that you process on a daily basis are performed.

Biochemistry is a fascinating and vast subject and if this article has sparked your interest, further reading is certainly recommended.

Part three of this series will discuss the results obtained from the haematology analyser and introduce some basic bacteriology. In the meantime, the author suggests that you start looking at the biochemistry results you process in your practice and see if you can spot any patterns linking the results to the patient's condition. [vni](#)

#### Further reading

BSAVA Manual of Clinical Pathology (Second Edition) edited by Elizabeth Villiers & Laura Blackwood. BSAVA, Gloucester (2005) ISBN 978 0 905214 79 5.

## NEWS REVIEW

by Jean Turner

### TP Congress 2013 18th-19th March 2013

Registration for the College of Animal Welfare's Training Practice Congress 2013 is now open and this year there are a few changes.

First, TP Congress is moving to the MKCC Conference Centre in Milton Keynes – a modern, purpose-built conference centre conveniently located just off the M1. Second, the congress includes an all-Clinical Coach programme.

A technical update from Jack Ward, Chief Executive Officer City & Guilds, will lay out plans for the future and give delegates the opportunity to ask any questions they may have.

Kathy Kissick, chairman of the RCVS VN Council, will provide an update on both regulation and important legislation that all vets and nurses need to know. She will also look at what exactly students are allowed to do whilst training and what they should know upon qualification.

Nick Stace, RCVS chief executive and secretary, will lay out his plans for the profession for 2013 and Pam Mosedale from the BSAVA will discuss the legal requirements of dispensing.

A full agenda and booking information can be found at [www.caw.ac.uk](http://www.caw.ac.uk) or by calling 01480 422060. £190+VAT for one day and £285+VAT for both days.. [vni](#)

### Birth alarm for foaling

It's that time of year when anticipation starts to mount about the arrival of new foals. For some, this can spell long sleepless nights and cold dark yard visits to check on mares about to foal. For those who would like to make those sleepless nights a thing of the past, Gallagher Europe, claims to have the answer.

Birth Alarm is a foaling alarm that sends you an alert when the mare goes into labour. It includes both a transmitter and a receiver, and depending upon the model you choose, it can either be fitted to the mare's withers (onto an anti-cast or normal roller) or her halter.

According to the manufacturer, the transmitter is triggered, and an alarm

sounded as soon as the mare's contractions begin. It can also be used in combination with a webcam.

For further information, visit [www.birthalarm.com](http://www.birthalarm.com) or contact Andrea Worrall or Steph King on 01608 654040 or e-mail [media@thegpc.co.uk](mailto:media@thegpc.co.uk) [vni](#)

### Italian Spinones needed for survey

A health survey for Italian Spinones, born between 1st January 2000 and 31st December 2011 is being undertaken by the Kennel Club and the Animal Health Trust. This, it is hoped, will help improve the understanding and treatment of cancer, epilepsy and gastric dilation/torsion in this breed.

Please ask clients who own the breed, and whose dogs are Kennel Club registered, to complete the questionnaire which is available on the AHT website, [www.aht.org.uk/cms-display/italian\\_spinone\\_questionnaire.html](http://www.aht.org.uk/cms-display/italian_spinone_questionnaire.html)

The data generated should help researchers at the Kennel Club Genetics Centre at the AHT. [vni](#)