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Essentials of Fluid Therapy Mini Series

Session Two: The Practicalities

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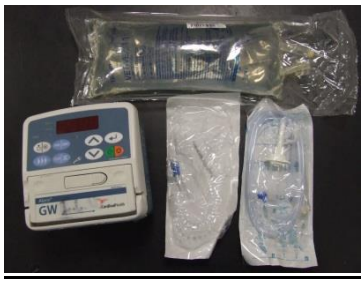


Webinar 2 Study Notes

Fluid Therapy in Small Animal Practice: Part 2 – The Practicalities

Classification of Fluids

A. Crystalloids – aqueous solutions of salt or other water soluble molecules. Crystalloids are classified according to the tonicity of the solution when compared to that of plasma and can be defined as hypotonic, isotonic or hypertonic. This tonicity determines how the fluid will distribute in the body after administration. Using the definitions of osmolality and tonicity, a hypotonic solution will therefore have fewer osmotically active particles than an isotonic or a hypertonic one, and is less effective at drawing water into a body compartment. Canine plasma has an osmolality of approximately 300 mOsm/kg. Hartmann's solution has an osmolality of 272 mOsm/kg and is therefore slightly hypotonic. However, it is close enough to plasma osmolality that it is commonly regarded as being isotonic.

Crystalloids may be referred to as maintenance or replacement fluids. Replacement fluids have a similar composition to extracellular fluid and are used to replace lost water and electrolytes. Replacement fluids can be balanced (similar composition to plasma e.g. Hartmann's) or unbalanced (e.g. 0.9% NaCl). Maintenance fluids have less sodium and more potassium. Maintenance fluids can be bought commercially – for example Normasol® M or Plasma-lyte® M – or can be made using a recipe.

1. **Isotonic Crystalloids -** when infused, there is no concentration gradient between the intracellular and extracellular spaces, and no movement of water occurs. Distribution within the body will reflect the compartment sizes i.e. only 25% of a replacement fluid will remain in the intravascular space after approx. 1 hour. For this reason, 3 - 4 times the replacement volume is required when using an isotonic crystalloid to replace a vascular fluid deficit.

i. Hartmann's solution – very commonly used in the UK. This is the most suitable for fluid resuscitation and perioperative fluid therapy. It is alkalizing (contains bicarbonate precursor). DO NOT infuse in the same line as blood. Unsuitable for hypercalcaemia or severe liver disease. Should Hartmann's be used for lactic acidosis? Remember that the key to therapy here is to restore circulating volume and tissue perfusion. This will encourage cells to switch back to aerobic metabolism. Once this occurs, the lactate is rapidly cleared by the liver.

ii. Normal (0.9%) saline – higher Na and Cl than plasma. Acidifying because bicarbonate is diluted and the high concentrations of chloride lead to a hyperchloraemic acidosis. Therefore it is not the fluid of choice in acidaemic patients. Infusing 0.9% NaCl will also lead to a dilutional hypokalaemia.

iii. Plasmalyte® 148 and Normosol R® are also replacement fluids but contain magnesium (hypomagnesaemia is often present during critical illness) and have acetate as the bicarbonate precursor. Neither have a license in animals.

2. **Hypertonic Saline** - 7.2% saline and very hyperosmolar (2400 mOsm/kg). Not commonly used in small animals but is very effective at rapidly restoring circulating volume (often called 'small volume resuscitation') Doses are approx. 4 – 7 ml/kg (dog) and 2 – 4 ml/kg (cat).

Since its tonicity is so high – and therefore it contains a large number of particles – it has the ability to draw in fluid from the intracellular and interstitial spaces and rapidly restores circulating volume within minutes. Its main advantage is that only a very small volume of hypertonic saline is required and can be given relatively quickly, over 2 – 5 minutes. Potential benefits are its rapidity in restoring blood pressure, improved cardiac contractility, improved oxygen delivery to tissues (improved micro-perfusion) and lower intra-cranial pressure following resuscitation. However, it is short-acting and infusion must be followed with an isotonic crystalloid to replace fluid lost from the interstitium and from cells. Due to its high sodium and chloride content, hypernatraemia and hyperchloraemia are inevitable. Other side effects include small vein irritation, and hypertonic saline should be infused through a large vein and preferably a central vein; intravascular haemolysis; ventricular arrhythmias, and the electrocardiogram should be monitored during administration if possible. It should be noted that the presentation of hypertonic saline in clear fluid bags is very similar to that of other fluids. It should be kept apart from isotonic and hypotonic fluids to prevent the inadvertent mistaken administration, as this can be rapidly fatal if given in large volumes.

Contra-indications of hypertonic saline administration

1. Uncontrolled haemorrhage – for example the haemoabdomen that arrives at the practice in shock. In this case, the rapid restoration of blood pressure may worsen the haemorrhage, or indeed dislodge a clot and cause the continuation of bleeding. In these cases some suggest hypovolaemic resuscitation, such that blood pressure is restored, but not to normal levels. In this way, perfusion of vital organs is probably maintained, but haemorrhage is not worsened. It is probably safe to do this in the very short term until diagnostic investigation can pinpoint the source. However, this relies on the facility to measure blood pressure in the clinical setting and this isn't always the case in practice. Ideally, these animals should have arterial catheters placed and invasive monitoring performed.

2. Dehydrated animals are not suitable candidates for hypertonic saline. Intracellular water reserves are low in these animals, and cellular dehydration will be worsened by the administration of hypertonic saline. It may be acceptable to use small volumes with the concurrent administration of isotonic saline. In reality, dehydration is a chronic problem and as such should not require rapid volume restoration except in those patients in extremis.

3. **Hypotonic Crystalloids** - have fewer osmotically active particles than plasma or extracellular fluid, and therefore when that fluid is infused, water will move out of the blood vessels and extracellular space and into the cells. It is used when the loss experienced by the patient is hypotonic – that is pure water loss. An example of this would be water deprivation. In these patients the extracellular fluid becomes hypertonic as more and more water is removed. 5% dextrose in 0.45% saline would be the fluid of choice. Although initially, this fluid has a relatively isotonic osmolality, once the dextrose is metabolised, essentially all that remains is water. Note that the calorific content of 5% solution does not provide the energy requirements for patients. Hypotonic solutions can be mixed with isotonic solutions to produce maintenance fluids.

Commercially available maintenance fluids – Plasmalyte M® and Normosol M® - are also hypotonic. There are very few indications for the administration of hypotonic fluids.

B. Colloids

Colloids are primarily used for volume expansion and patients with hypoproteinaemia. Unfortunately, at the time of writing, availability is limited. Recent human meta-analyses demonstrate that colloids are associated with similar or worse outcomes when used for volume resuscitation in critically-ill patients. They can be administered at the same time as a crystalloid, to provide sustained blood volume support. Colloids are described according to their molecular weight – usually expressed in kilo Daltons (kD) - and the number of particles. These 2 properties are important because the number of particles gives an indication of the potential osmotic pressure exerted by the colloid, and the molecular weight determines the duration of effect.

1. Human Albumin - prepared as a 25% pooled albumin product. There is very limited information regarding its use in veterinary patients, and although its popularity had been increasing over the last few years, its use is again waning. Currently it is difficult to buy in the UK and is expensive compared with other types of fluid. Even within human medicine, its benefits have not been fully elucidated, and some studies show that outcome is not improved following its administration. Human albumin is very hyperoncotic and may be useful in sepsis syndromes, but cannot be recommended for use at this time. Risk of anaphylaxis is high.

2. Gelatin – There are no licensed products in the UK – currently Gelofusine® is available. It is produced from bovine collagen, and has a low molecular weight when compared with the starches (30 kD). Gelatin is relatively short acting as the product is quickly broken down and excreted, with a reported half-life of 8 hours, but clinically this appears to be much shorter. Despite having fewer side effects, the incidence of non-allergic anaphylaxis appears to be greater compared with other colloids. Gelatins do prolong bleeding times, but to a lesser extent than the colloids with larger molecular weights. The effect of gelatin on coagulation should be taken into account when considering its administration to a patient with a coagulation disorder as there appears to be a direct correlation between the amount of colloid administered and bleeding times in humans. Gelatins are rapidly eliminated through the kidney.

3. Dextrans - made from bacterial polysaccharides. They have never been popular in veterinary medicine, particularly in the UK and will not be discussed further.

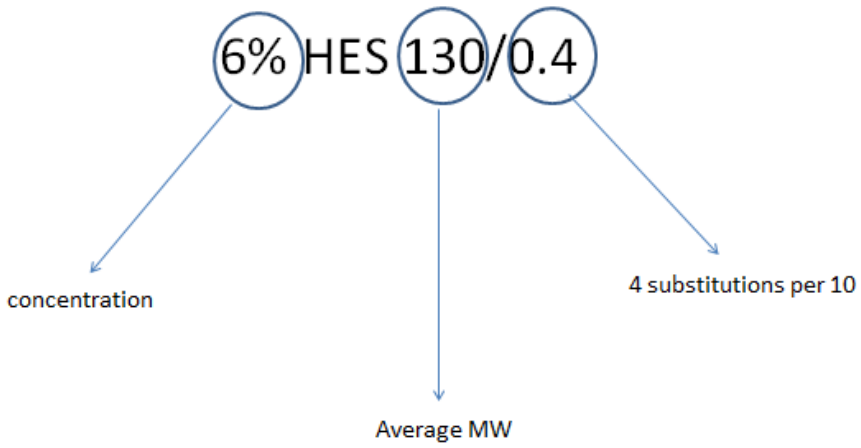
4. Hydroxyethyl starches (HES) - described by 3 numbers on the bag (see Figure 1):

i. **Concentration** – this is expressed as a percentage and gives an indication of the initial volume effect when colloids are administered. For example, 1 litre of a 6% hydroxyethyl starch, when infused, generally has the same volume-expanding effect as 1 litre of blood and is termed iso-oncotic (note the difference here between isotonic used to described crystalloids, and iso-oncotic used to describe colloids). But, a 10% hydroxyethyl starch has a volume effect exceeding the infused volume – that is it draws in more fluid than the blood it has replaced, and is therefore termed hyperoncotic.

ii. **Molecular weight** – synthetic colloids are polydisperse containing a wide variety of differently weighted molecules. The second number on the bag gives an indication of the *average* molecular weight of the product. Small particles are excreted very quickly but lots of small particles exert greater osmotic pressure. Larger particles stay in the circulation longer, but because there are fewer of them, exert a smaller osmotic effect. After a colloid is infused, the small particles are rapidly excreted by the kidneys, and so the osmotic pressure exerted by the colloid continually reduces. This is compensated for by the degradation of the large molecules into lots of smaller molecules. The average molecular weight varies between starches and ranges from 70 to 670 kD and the starches can provide effects for up to 24 hours in dogs.

iii. **Molar substitution** – is a tricky concept, but an important one nevertheless. The starches are polymers – repeated smaller units joined together to form a larger one. For starches these small units are glucose molecules. Hydroxyethyl starches have varying numbers of these glucose units substituted with hydroxyethyl residues. These substitutions increase the solubility of the polymer and inhibit its breakdown. This substitution is reported on the label as a ratio. A molar substitution of 0.7 represents 7 hydroxyethyl residues per 10 glucose subunits and is termed a HETASTARCH. Likewise, a ratio of 0.6 is 6 residues per 10 subunits and is termed a HEXASTARCH, and a PENTASTARCH would have a ratio of 0.5.

Figure 1 – the numbers displayed on a bag of colloid



So, as clinical examples, a 10% hydroxyethylstarch 200/0.5 is a hyperoncotic pentastarch with an average molecular weight of 200 kD; a 6% hydroxyethylstarch 600/0.7 is an iso-oncotic hetastarch with an average molecular weight of 600 kD.

Side Effects of Colloids

There are 3 main side effects that the clinician needs to be aware of:

1. **Volume overload** – because the effects of colloids are relatively slow, and fluid continues to be drawn into the vascular space after administration, patients are at risk of volume overload if doses are not adhered to. Most patients are able to deal with fluid overload by excreting excess fluid. However, cases prone to pulmonary oedema – for example, patients presenting with systemic inflammatory response syndrome, or acute respiratory distress syndrome and other shock states – and animals with congestive heart failure or renal failure should be monitored closely, and conservative doses used.
2. **Anaphylaxis** – can occur with all of the colloids. However, the mechanism is unclear, and there may be an antigenic component, or just the liberation of histamine. Either way, the clinical signs are the same, manifesting as tachycardia and hypotension, bronchoconstriction, flushing and urticaria, and therefore the management is the same too. Stop administration of the offending product, perform CPR if necessary, or support the patient's cardiovascular system as appropriate with vasoactive agents. Antihistamines and the administration of steroids may be useful, although once the reaction has occurred, this is often ineffectual. To attempt to minimise the risk of these reactions developing, infuse at low rates for the first 15 – 30 minutes.
3. **Coagulopathy** – least affected by the gelatins and most affected by dextrans. The starches seem to have an intermediate effect but this is determined by the type of starch and its associated properties described earlier. Starches with a smaller substitution ratio appear to affect coagulation to a lesser degree. The effect on the coagulation cascade is related to reduced concentrations of Factor VIII and von Willebrand factor, altered fibrin formation and impaired platelet function. Clinically significant coagulopathies have been reported with the older hydroxyethyl starches in humans. Newer starches with lower substitution ratios may not have clinically significant effects if administered at recommended rates. The new generation of tetrastarches appear to have a highly improved safety profile and are likely to be the colloid of choice in a patient with a pre-existing coagulopathy.

Clinical Colloid Doses

This is very dependent on the patient, its condition and presenting clinical signs. An animal with acute blood loss is likely to require a faster and larger dose of colloids than one that has been losing for fluid over a longer time period. Generally speaking, the recommended total dose of a colloid in any 24 hour period is 20 ml/kg (dog) and 15 ml/kg (cat). Much larger doses have been administered to experimental animals, but adverse effects are more likely at doses above those recommended. The rate of administration can vary, but rates should be low to begin with and the animal monitored for signs of anaphylaxis.

Blood Transfusion

With the advent of a Pet Blood Bank in the UK, more practitioners have access to canine blood products for transfusion. Unfortunately, the unpredictable supply of canine blood in the UK means that it is still advisable to have access to a list of healthy donor dogs. Currently, there is no feline blood bank and all transfusions necessitate having access to donor cats.

Blood contains allogenic cellular material that can be highly immunogenic. Therefore, the incidence of adverse reactions is greater than with other fluid products. Transmission of infectious disease is possible and immunological reactions can be catastrophic. Furthermore, the cost of administering a blood transfusion means it is not appropriate for all cases.

Blood types – The dog erythrocyte antigen (DEA) system is used in dogs and the AB system in cats. In the dog, DEA 1.1 and 1.2 are the most significant. A 'universal donor' would be negative for DEA 1.1, 1.2, 4 and 7. More recently a new antigen ('*Dal*') has been identified which may cause significant transfusion reactions. Naturally occurring antibodies to these antigens are unusual in the dog. As such, it is acceptable to transfuse a dog without any history of a previous transfusion, without crossmatching or blood-typing. However, ensuring a good match does increase the longevity of the donation. Once transfused, dogs will produce antibodies to foreign antigens and further transfusions are contraindicated without performing a cross match. Unfortunately, cats do have naturally occurring antibodies and it is essential to type all cats prior to any transfusion and donation and preferably to crossmatch too. Transfusing a type B cat with type A blood can be rapidly fatal. Recently the '*Mik*' antigen has also been identified in cats. Blood typing in both dogs and cats is straightforward with commercially available kits. The details of cross matching will not be described here.

The term 'Transfusion Trigger' has been used extensively within the literature. In animals, it is necessary to extrapolate from the human guidelines. For acute haemorrhage, blood loss of 10 – 15% is suggested as a trigger for a blood transfusion. Otherwise, a packed cell volume of 21 – 25% or a haemoglobin concentration of < 7g/dl would be considered trigger points for transfusion. In humans, the Association of Anaesthetists of Great Britain & Ireland publish guidelines:

- No transfusion of if [Hb] > 10 g/dl
- A strong indication for transfusion if [Hb] < 7 g/dl
- Transfusion essential if [Hb] < 5 g/dl
- [Hb] of 8–10 g/dl is considered safe even in patients with significant cardiorespiratory disease, but symptomatic patients should be transfused
- Surgical blood loss can be estimated by measuring the amount of blood within closed suction systems. The fluid used for lavage must be subtracted from this. Otherwise, a soaked standard (10 cm x 10 cm) swab can be estimated to contain 10 ml blood. Swabs can also be weighed and 1 ml of blood weighs approximately 1.05g.

Before infusion:

1. Check IV access – preferably use a dedicated catheter if possible. Blood can also be administered intraosseously.
2. Check the blood unit for suitability (species, expiry date, storage, colour etc.). Discoloured blood should not be infused.

3. Choose suitable infusion equipment – a giving set with a blood filter, check pump is suitable for use with blood.
4. Warm the blood if necessary using a water bath (not the microwave!). Place in a second bag before placing into the water bath to prevent contamination of the ports.
5. Strict asepsis when setting up a transfusion
6. Calculate the volume to be administered
7. Keep a record

Commence at low rates initially, increasing the rate if no reactions are noted (Table 1). The required volume of blood can be calculated using an equation:

$$\text{blood volume required (mls)} = \text{circulating blood volume} \times \frac{\text{required PCV - recipient PCV}}{\text{donor PCV}}$$

where circulating blood volume is 80 – 90 ml/kg for dogs and 50 – 60 ml/kg for cats.
Aim to have the transfusion completed within 4 hours to minimise the risk of contamination. Transfusion reactions can vary in severity from mild clinical signs such as depression, anxiety and agitation, to more severe cardiorespiratory signs (tachycardia, arrhythmias and tachypnoea) and seizures. Note that reactions can be masked somewhat in animals under general anaesthesia. The patient must be closely monitored throughout the transfusion, although the first 30 minutes are the most vital.

Oxyglobin

This is a haemoglobin oxygen carrying solution. It is manufactured from bovine haemoglobin and contains no cellular (and therefore no antigenic) material. It is used as a blood substitute in the UK in both dogs and cats. The advantages and disadvantages are listed below:

- 3 year shelf-life provided the foil pouch is not opened
- Can be stored at room temperature
- Available in 60 and 125 ml bags
- Enhances tissue perfusion and oxygen delivery (no cells therefore less viscous)
- Half-life of 30 – 40 hours
- Licensed for a single transfusion to dogs
- Has been used successfully in cats and in animals needing multiple transfusions (off label use)
- Can be administered using normal infusion equipment
- Hyperoncotic and can lead to hypervolaemia (especially in cats)
- Causes a dilutional fall in PCV and coagulation factors
- Discolours urine, faeces, skin and membranes

- Affects colorimetric biochemical tests, urine dipsticks, refractometric total solid measurements and optical coagulation tests

Table 1 – dose and rates for blood transfusion. Adapted from BSAVA Manual of Canine and Feline Anaesthesia and Analgesia (3rd Ed), with permission

Product	Dose	Dose rate
Whole blood	Calculate using the equation. As a rough guide 10 – 22 ml/kg	Start at a low dose 0.25 – 0.5 ml/kg/hr then infuse at 1 – 4 ml/kg/hr. The rate can be increased if necessary to up to 20 ml/kg/hr Complete the infusion within 4 hours
Packed red blood cells	Calculate using the equation. As a rough guide 6 – 10 ml/kg	Start at a low dose 0.25 – 0.5 ml/kg/hr then infuse at 1 – 4 ml/kg/hr Complete the infusion within 4 hours
Fresh frozen plasma	6 - 10 ml/kg but can be repeated	Start at a low dose then increase up to 6ml/kg/hr. Complete the infusion within 4 hours
Oxyglobin®	15 – 30 ml/kg	Maximum 10 ml/kg/hr. Use much lower rates for normovolaemic animals Rates should be even lower for cats since they are more at risk of volume overload. Rates of 0.5 – 2 ml/kg/hr have been suggested.

Monitoring of Fluid therapy

The key to managing fluid therapy is frequent patient reassessment during infusion. Changes can occur quickly so it is advisable that reassessment is carried out frequently, with more critical patients requiring constant monitoring if facilities allow. Intravenous administration of fluids can obviously lead to rapid changes that may need to be addressed. Remember that fluids should be treated as drugs and not thought of as benign.

The most basic monitoring of the cardiovascular system entails an assessment of mucous membrane colour, capillary refill time, and pulse quality.

1. Mucous membrane colour and capillary refill time (CRT) - assuming normal haemoglobin levels, assessment of these two variables gives some idea of peripheral perfusion. Information can be derived from mucous membrane colour as detailed in Table 2.

Table 2 – interpretation of mucous membrane colour

Mucous membrane colour	Significance
pink	normal
pale	vasoconstriction
congested	vasodilation
cyanotic	> 5 g deoxygenated Hb per 100 ml blood
grey	circulatory failure

There is no correlation between mucous membrane colour and arterial blood pressure. Normal CRT is less than 2 seconds but can be misleading as capillaries can refill from distended veins as well as arteries; it is perfectly possible to obtain a normal CRT in a freshly dead animal.

2. Palpation of peripheral pulses - palpated at a variety of areas in dogs and cats
    - Dog – femoral, lingual, brachial, radial, cranial tibial, coccygeal, auricular
    - Cat – femoral ,brachial, cranial tibial, coccygeal

    It is important to palpate peripheral arteries rather than central ones, as the former are much more sensitive to changes in cardiovascular function. For example, marked decreases in arterial blood pressure may result in minimal palpable changes in femoral pulse quality, but obvious changes (and perhaps even disappearance) are likely to be observed in peripheral arteries. It is important to recognise exactly what pulse palpation tells you: the pulse pressure (pulse strength) is merely the difference between systolic and diastolic pressure - an animal with an arterial blood pressure of 120/80mmHg will have similar pulse strength to one with arterial pressure of 80/40mmHg, i.e. the pulse quality reflects stroke volume, not blood pressure. Similarly, hypovolaemia results in a weak, easily compressible pulse but arterial blood pressure may be normal. However, peripheral pulse palpation can give a subjective indication of stroke volume if the clinician is familiar with this technique.
3. Arterial blood pressure monitoring - the main function of the cardiovascular system is to provide a flow of blood to tissues, such that oxygen and nutrients are delivered and waste products produced by cellular metabolic processes are removed. Blood pressure is a fundamental cardiovascular parameter that describes the force driving tissue perfusion, where blood pressure is the pressure exerted by blood on the walls of the arteries and arterioles of the systemic circulation. It also determines the workload of the myocardium (afterload). Blood pressure is commonly measured in millimetres of mercury (mmHg). Systolic arterial blood pressure (SAP) is the pressure exerted on the arterial walls during left ventricular contraction. Diastolic arterial blood pressure (DAP) is the pressure exerted on the arterial walls during ventricular relaxation due to the Windkessel effect (elastic recoil of arteries and arterioles). Mean arterial blood pressure (MAP) – is the average pressure exerted over the cardiac cycle and therefore is a determinant of tissue perfusion. Arterial pressure can be measured in 2 ways:
    a. Direct arterial blood pressure monitoring gives more accurate and continuous information compared to indirect methods. It is the gold standard for measurement of arterial blood pressure and also allows for sampling of arterial blood for blood-gas analysis.

It is essential that the clinician is familiar with the limitations and complications of direct arterial blood pressure measurement and its potential inaccuracies. It is performed by catheterisation of an artery, and connection of the catheter to a device which gives a reading of arterial pressure. Commonly, the catheter is connected to a transducer - a device which converts the pressure signal from the artery into an electrical signal - and then to an electronic monitor, which provides a display of the arterial pressure trace, as well as values for systolic, mean and diastolic pressure. Alternatively, the catheter can be connected to an aneroid manometer to give mean arterial blood pressure values.

b. Indirect arterial blood pressure monitoring - is both less technically demanding, and associated with lower morbidity, than invasive measurement, since arterial catheterisation is not required. However, the technique is also less accurate and does not give continuous readings. In addition, the presence of cardiac arrhythmias and hypotension may lead to inaccuracies. Two indirect methods are used in veterinary practice:

   i. Doppler ultrasonic flow method. In this technique, a small probe is positioned over a peripheral artery (usually, tail or paw). As blood flows along the vessel underneath the probe, a “whooshing” noise is emitted by the monitor. If an inflatable cuff, connected to an aneroid manometer, is placed further up the limb and sufficiently inflated, it will occlude the artery and the noise will disappear. If the cuff is now slowly deflated, the sound will reappear at systolic arterial pressure, which can be read off the manometer. In dogs, good correlation is observed between measured Doppler systolic arterial pressure and that provided by direct femoral arterial catheterisation, but in cats, the system tends to under-read the true systolic pressure, and it has been suggested that a correction factor of approximately 14mmHg has to be added to the observed reading. More recently it has been demonstrated that there is greater correlation in cats, between directly measured mean arterial pressure and that measured by the Doppler system. Thus, although this technique is being used to assess systolic arterial pressure, due to inherent inaccuracies in the system, the value obtained in cats probably more closely correlates to the mean arterial pressure.

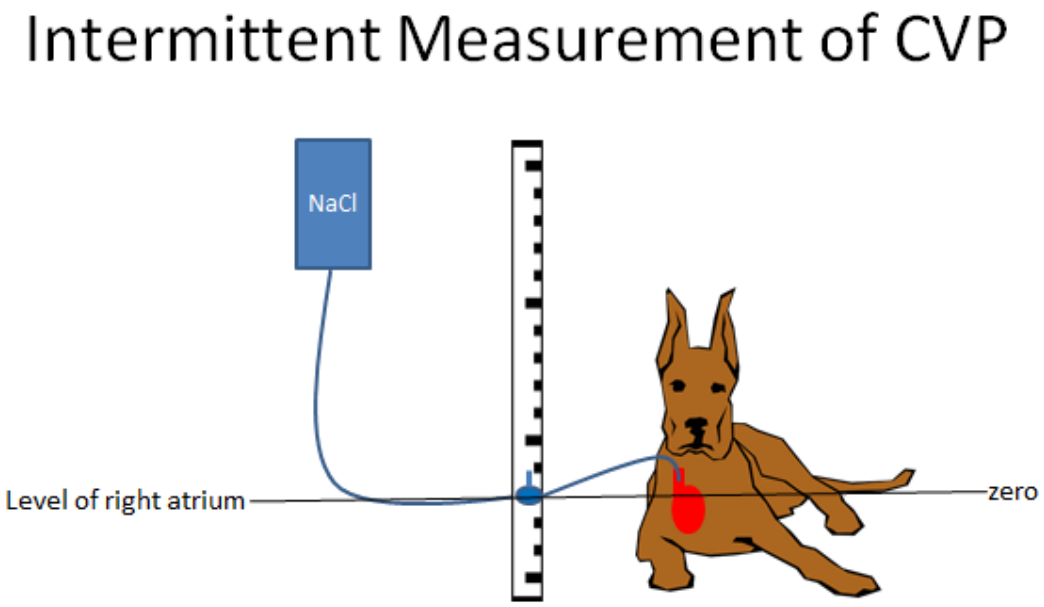
   ii. Oscillometric method. These machines comprise a cuff system coupled with an electronic monitor. The cuff is placed over a peripheral artery and the machine automatically inflates the cuff to occlude the artery, before slowly releasing the pressure. As the cuff deflates, the machine detects oscillations in the artery as the blood begins to flow back through, oscillations beginning at systolic pressure, reaching a maximum at mean pressure, and gradually disappearing at diastolic pressure. Thus, unlike the Doppler system, the oscillometric technique gives readings of all 3 blood pressure points. It can also be set to cycle automatically, thereby giving regular readings, whereas the Doppler technique has to be performed manually each time. With the oscillometric technique, the mean reading is most reliable, followed by the systolic, while the diastolic should only be considered moderately accurate. Cuffs are commonly placed around the cranial tibial (dorsal pedal) artery at the metatarsal area,

the radial artery just above the carpus, or the coccygeal artery in the ventral tail. Older oscillometric machines were extremely unreliable in small dogs and cats, often failing to display any blood pressure reading whatsoever. However, newer machines are available which, to some extent, have overcome this problem. Since oscillometric devices generally record the pulse rate as well as the arterial pressure, it is always worth checking that the displayed value is equivalent to a manually recorded pulse rate, before placing any reliance on the blood pressure reading. Similarly, inaccurate oscillometric arterial pressure results commonly occur if cardiac arrhythmias are present – even normal variants such as sinus arrhythmia. If this is the case, Doppler or direct arterial blood pressure monitoring will provide more accurate results.

With both the Doppler and oscillometric techniques of blood pressure measurement, the size and positioning of the occluding cuff used is critical in obtaining accurate results. The width of the cuff should be approximately 40 - 60% of the circumference of the area it is placed around: cuffs which are too small will result in an over-reading of the blood pressure and vice versa. In addition, the occluding cuff should be positioned level with the heart: arterial pressure will be erroneously high if the cuff is below the heart, and erroneously low if above it. Applying cuffs too tightly around the appendage will result in an under-reading of the blood pressure, while applying them too loosely will cause an over-reading. While direct arterial pressure monitoring gives reliable results on a beat-to-beat basis, indirect techniques should probably be considered more useful for following trends in pressure, rather than for absolute values. Despite being less accurate, however, indirect techniques are particularly convenient because of their ease of use and limited reliance on technical skills on the part of the anaesthetist.

4. Central venous pressure (CVP) – correlation between fluid requirement and CVP measurement is poor (at least in humans). Therefore, CVP measurement is not used as extensively as it may have been in the past. A central catheter is necessary which involves the placement of a catheter into a jugular vein. Management of these catheters becomes more problematic and intensive nursing is recommended. There are risks associated with central catheters which must be taken into account and prevented e.g. air embolism which can be catastrophic. Placement of the catheter usually necessitates sedation or anaesthesia and there is a steep learning curve associated with placement. The catheter is placed using the Seldinger (over the wire) technique. Once connected to a manometer or electronic monitor, the pressure displayed will be that in the cranial vena cava or the right atrium, depending on the length of catheter used. As right atrial pressure is an indicator of preload (the volume of blood returning to the heart), it can give some information on vascular volume, but must be interpreted with caution

Figure 2 – measurement of CVP



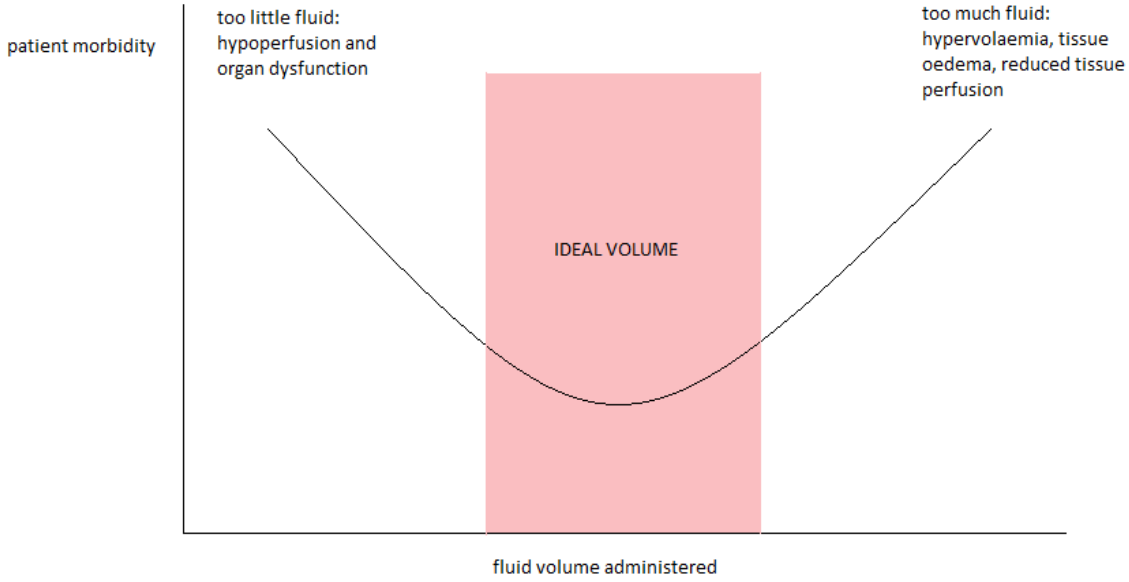
The illustration above (Figure 2) is a schematic representation of CVP measurement in practice, although the catheter can be connected to a digital monitor via a transducer as for invasive arterial pressure.. The animal must be positioned in the same way each time. The catheter is connected to a 3 way stopcock and a saline filled column. The zero position (at the level of the right atrium) needs to be taken into account when reading the meniscus of saline. Normal CVP is less than 10 cmH_2O. It is of absolutely no value to measure CVP once; serial measurements should be made to give an idea of trend. At each measurement point, 3 or 4 measurements should be taken and a mean calculated. Suggested endpoints for fluid therapy using CVP are a 2 – 4 cmH_2O rise following a bolus of fluid, which returns to baseline after 15 minutes. It must be interpreted with other parameters.

5. Urine output – although an indwelling urinary catheter is preferable, weighing of soaked pads can be used as an estimate for urine output. Normal values are in the region of 0.5 – 2.0 ml/kg/hour. It is important to measure urine specific gravity (see Webinar 1) to assess kidney function.
6. Lactate – serial measurements must be used. Look for a downward trend. Normal values are < 2.0 mmol/l. Prognosis becomes guarded if lactate is continuing to rise despite fluid therapy. It may be that the fluid therapy plan is not appropriate.
7. Cardiac output – this is the gold standard for determining vascular volume. There are a variety of invasive and less invasive techniques but none are suitable for general practice.

Goal Directed Therapy (GDT)

This has become a term used commonly in human critical care practice. Figure 3 is a schematic representation of relationship between patient morbidity and fluid therapy.

Figure 3 – Patient morbidity associated with fluid therapy (With permission, BSAVA Manual of Canine and Feline Anaesthesia and Analgesia (3rd Ed))



In humans, GDT is based upon optimisation of stroke volume and cardiac output. Unfortunately, measuring these indices is invasive and comes with significant risk and costs. Therefore they are not commonly measured in animals. Note from the diagram that over or under hydration can lead to consequences, but it remains essential that hydration is achieved EARLY to ensure good survival.

Normalisation of clinical signs is often used as GDT in animals:

1. Heart rate
2. Blood pressure
3. Urine output
4. Lactate