Fluid Therapy and Transfusions
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Fluid therapy is commonly used in small animal practice. It can be of value to help correct abnormalities in circulating volume, electrolytes and acid base abnormalities. It can also be of value to help manage a number of different metabolic diseases and toxicities. Fluid therapy also plays a central role in the management of patients in shock. Fluid therapy can also play a supportive role during anaesthetic and surgical procedures. It is important to remember however that fluid therapy is supportive, and the underlying disease process that necessitated fluid therapy needs to be diagnosed and treated. There are a number of things that need to be considered when formulating a plan for fluid therapy in a patient. These include the volume of fluids, the rate the fluids need to be administered, the type of fluid, the route of administration, additives required, and when the fluid therapy can be discontinued.

Fluid Distribution

Between 60 – 70% of an adult animal's body weight is comprised of water, and can vary with age, sex and body composition. This percentage is typically higher in young animals. In humans total body water is lower in women. Fat has a lower water content than does lean tissue, so fluid requirements should ideally be calculated based upon lean body mass. Body fluids are distributed between several physically distinct compartments. Approximately two thirds of body water is located within the intracellular compartment (intracellular fluid or ICF), and the remainder of the fluid is in the extracellular compartment. The extracellular fluid (ECF) is then distributed between different compartments. About 75% of the ECF is so called interstitial fluid that is distributed between cells. The remaining 25% is within blood vessels and is referred to as intravascular fluid (plasma). The ECF is more susceptible to changes in hydration, and this is where fluid losses occur initially.

In addition to water the body fluids contain solutes, such as electrolytes, minerals, acids etc. These solutes are not evenly distributed between the different fluid compartments (ICF vs ECF), and the vascular endothelium and cell membranes have different permeability for different solutes. The vascular endothelium is relatively impermeable to blood cells and plasma proteins. It is however relatively permeable to ionic solutes, so the concentration of these is similar in the plasma and interstitial fluid. The cell membranes function to maintain very different solute concentrations in the ECF and ICF, with sodium and chloride in high concentrations in the ECF, and potassium and phosphates in higher concentrations in the ICF. The number of osmotically active particles in each space determines the volume of fluid in the ECF and ICF compartments. In addition to the electrolytes, glucose and urea have potential osmotic activity. The solutes exert an effect in the solution based on the number of particles. Osmolality refers to the number of osmoles per kg of solvent. This can be measured with an osmometer, or can be calculated using a formula such as that below.

$$\text{ECF osmolality (mOsm/kg)} = 2(\text{Na} + \text{K}) + \text{Glucose} + \text{Urea}$$

Normal osmolality is between 290 and 310 mOsm/kg, and for cats is between 308 and 335 mOsm/kg.
In disease states fluids and solutes are lost primarily from the ECF initially. The fluid lost may be hypotonic (fluid in excess of solute), isotonic (solute and fluid lost in proportion), or hypertonic (solute in excess of fluid). If hypertonic fluid is lost, the ECF osmolality decreases relative to the ICF, so fluid will move from the ECF to ICF until the osmolalities equalize, further decreasing the ECF volume.

Colloids are large molecular weight particles present in a solution, and plasma proteins are the primary colloids in plasma. They contribute to the plasma oncotic pressure.

With respect to movement of fluid between the plasma and interstitial spaces, there are a number of forces that help manage the movement of fluid across capillary membranes. These are the capillary hydrostatic pressure, interstitial hydrostatic pressure, capillary oncotic pressure and interstitial oncotic pressure. The capillary pressures are the most important. At the arterial end of capillaries there is a movement of fluid into the interstitial space, and at the venous end there is a movement of fluid into the capillaries. The net movement of fluid is out of the capillaries into the interstitial space, but the lymphatics remove this fluid and send it back into the circulation. A reduction in capillary oncotic pressure (as seen with hypoalbuminaemia) can allow fluid to move into the interstitial space.

**Determining If Fluids Are Required**

The collection of an appropriate history and performing a thorough physical examination can help determine if fluids are required in patients that present unwell. It is important to note that in some cases fluids may be commenced before the collection of a complete history and physical examination. For example a patient presenting in shock requires fluid therapy urgently. In other cases such as anaesthesia and surgery the fluids are administered as part of a protocol.

Shock may be hypovolaemic in nature, as a result of trauma, blood loss, or severe dehydration. Distributive shock can be the result of vasodilation, such as may be seen with an anaphylactic reaction perhaps. In these situations the patient may present with a history or obvious signs of trauma, or reduced mental state, tachycardia, pale membranes, prolonged capillary refill, weak or absent pulses and hypotension. In these cases immediate and aggressive fluid therapy is required to save the patient. Cardiogenic shock as a result of congestive heart failure, cardiac tamponade or severe arrhythmias should not be treated with aggressive fluid therapy.

Fluid therapy is indicated in patients that are dehydrated. In the normal animal fluid input is via drinking, eating and production of water associated with metabolism. Fluid losses occur through the urine, faeces and respiratory tract. Cutaneous fluid loss is significantly less in animals than people.

Historical information that may suggest dehydration is likely could include causes of reduced intake such as reduced thirst or inappetance, or increased fluid loss as a result of polyuria, vomiting or diarrhoea. There can be third space fluid loss, when there is reduced circulating fluid volume, but the fluid lost remains in the body, such as gastrointestinal obstruction or gastric dilatation-volvulus, or fluid accumulation in body cavities. Patients with large cutaneous wounds may also lose fluid, and patients that are bleeding also lose volume.

There are a number of features of physical examination that may support dehydration. These can include how moist mucous membranes are, capillary refill time, eyeball position within the orbit, heart rate, pulse strength, skin turgor etc. Whilst when evaluated in combination these features can help determine the extent of dehydration, any one of them in isolation has limitations. For example cardiovascular disease can affect heart rate or pulse...
strength, and body condition can affect skin turgor. Body weight may also help determine fluid loss if it was previously known, and can be assessed for a hospitalized patient, but this can be complicated by third space losses. Dehydration less than 5% cannot be detected clinically, and once it exceeds 10-12% the patient will begin to manifest signs of shock and death is impending at 15%.

Laboratory tests can also be used to help determine if dehydration is likely or not. Very basic tests can include a PCV, total protein and urine specific gravity. If these values are all elevated, dehydration is likely. However in an animal with a disease process that impairs urine concentrating ability urine concentration is less helpful. The PCV and TP can be hard to interpret is baseline values were not known – for example values of 50% and 75 g/L may be within reference range, but if the baseline values were 40% and 60 g/L, then dehydration is likely. Other values such as an elevation in blood urea or creatinine may also indicate dehydration if there is not pre-existing renal disease.

The measurement of electrolyte levels and acid base status can also help determine the ideal fluid to select and also which additives should be included, and also can help guide the amount of additives required.

**Fluid Types**

There are a number of types of fluids available, and include crystalloids and colloids. Crystalloids are aqueous solutions that contain electrolyte and other water soluble molecules that are capable of entering all body fluid compartments, and so have effects primarily on the interstitial and intracellular compartments. Colloids contain larger molecular weight substances that are not able to pass through a normal, intact capillary membrane. They have their effect primarily in the intravascular compartment. Their effect on colloid osmotic pressure varies with their size – lower molecular weight substances have a greater effect on osmotic pressure as more molecules are in solution, but larger molecular weight substances persist longer in the circulation. They can be very effective in expanding vascular volume. Colloids can be natural (such as plasma, whole blood, or human serum albumin), or may be synthetic such as dextrans, gelatins, or hydroxyethyl starches (such as Voluven). Crystalloids can also be effective in expanding vascular volume, but require two to three times the volume compared to a colloid as they are also distributed to the interstitial and intracellular compartments.

Crystalloid solutions can be classified as balanced if they resemble the composition of the ECF. Examples of balanced solutions include Hartmann’s (also known as lactated Ringer’s solution), Normosol R, or Plasmalyte 148. Non balanced solutions do not resemble that of the ECF, such as normal (0.9%) saline. They can also be classified as replacement or maintenance solutions. The replacement solutions resemble the composition of ECF (see the fluids considered balanced earlier). The maintenance solutions, such as Normosol M or Plasmalyte 56, contain less sodium and more potassium than replacement fluids, and are designed to approximate what is lost from the body on a daily basis in the urine and faeces. Maintenance fluids can also contain glucose which helps increase the osmolality. These fluids are giving a larger proportion of free water than replacement fluids as the glucose is metabolized to CO2 and water.

Most of the replacement fluids contain a buffer, such as lactate, gluconate or acetate. These buffers are metabolized by the body to bicarbonate. Lactate (which is found in Hartmann’s solution) requires hepatic metabolism, so care should be taken in patients with hepatic failure, whereas acetate and gluconate can also be metabolized in muscle.

Hypertonic fluids such as 7.5% NaCl are sometimes used. Because of their hypertonicity they rapidly expand vascular volume because they draw fluid from the interstitial and
intracellular spaces into the vascular space. The volume expansion can match that achieved with colloids, but with a much smaller volume. As with crystalloid solutions there is redistribution to the interstitial and intracellular spaces, but they can be followed by other crystalloids or colloids to maintain the vascular expansion.

The chosen fluid may need to be supplemented with additives depending on the clinical situation. Such additives may include potassium chloride, potassium phosphate, sodium bicarbonate, glucose, calcium, or B vitamins. Potassium supplementation is required in many cases where potassium has been lost, and is required in maintenance fluids. The amount supplemented should ideally be based upon electrolyte measurements. Glucose may be added in patients that are hypoglycaemic, or in young animals that are at more risk of hypoglycaemia. The effect of the additives on other components of the fluid should be considered. Potassium phosphate should not be added to calcium containing fluids, and theoretically sodium bicarbonate should also be avoided in calcium containing solutions as calcium carbonate may form. It is important to consider that the additives used may increase the osmolality of the fluid, especially if 50% dextrose was added.

**Fluid Choice**

The choice of fluid will vary with the clinical situation, based upon potential diagnoses and laboratory testing. In a patient in shock a balanced replacement fluid will typically be used, without any additives. If there is a low albumin level the use of a synthetic colloid may be indicated. Hypertonic saline can also be used for a small volume resuscitation.

The fluid chosen should ideally approximate the nature of the fluid lost in the particular disease state. In the majority of patients that are dehydrated, a balanced replacement electrolyte solution will be used. As discussed previously, in the situation of hepatic failure lactate containing solutions may be avoided. In vomiting patients with a gastric outflow obstruction there may be significant loss of sodium, chloride, potassium and hydrochloric acid. These patients typically have hypochloraemia, hypokalaemia and a metabolic alkalosis. In this setting 0.9% NaCl is the more appropriate choice as it is an acidifying fluid. In patients with urethral obstruction or urinary retention with hyperkalaemia 0.9% NaCl is a suitable choice, and normal saline is often the initial choice in patients with hypercalcaemia to increase calciuresis. In a patient that may be sensitive to the effects of sodium (such as some patients in heart failure) a lower sodium fluid may be an option such as 0.45% NaCl with 2.5% dextrose. In patients that are hypoalbuminaemic a synthetic colloid solution may be chosen to help support plasma oncotic pressure. In patients that have coagulopathies, or in some diseases where specific proteins may be of benefit, plasma may be the fluid of choice. In an anaemic patient showing signs of compromise, blood products such as packed red blood cells or whole blood may be an option.

**Route of Fluid Administration**

**Intravenous**

The intravenous route is the one that is preferable and primarily chosen for fluid administration, especially in patients that are dehydrated, or are in shock. The intravenous route is the one typically chosen for patients under anaesthesia and having surgery, as it also allows vascular access for emergencies. Intravenous access allows a precise amount of fluid to be administered over a set period of time. In cases of shock if using a large bore catheter a large volume of fluids can be administered rapidly. Hypertonic fluids can be administered through a large vein.

Veins that can potentially be used for intravenous fluids include the jugular, cephalic, lateral saphenous, medial saphenous, and metatarsal. Jugular vein catheters can also allow
measurement of central venous pressure, and also allow blood sampling. Cephalic catheters are most commonly used. Catheters in the hind legs can be more challenging in patients with diarrhoea because of the risk of contamination. Over the needle catheters are most commonly used for intravenous fluids, but there are some through the needle catheters that are used for longer catheters. Appropriate skin preparation is important before catheter placement, with clipping and aseptic preparation. Ideally an occlusive dressing and bandage should be placed over the catheter. The catheter site should be examined once or twice a day for swelling, pain, discharge, erythema. Most catheters should be removed within 72-96 hours of placement, or sooner if there are any signs of complications. Hands should be washed before placing or handling catheters.

Catheter size will vary with the size of the patient and the rate that fluids need to be administered. In cats and small dogs a 20 – 22 gauge catheter in a peripheral vein is suitable for routine fluid administration, but a larger catheter may be placed if shock rate fluids are required. In larger dogs 18 – 20 gauge catheters may be used for routine fluids. If hypertonic fluids are to be administered through a peripheral vein a smaller catheter is ideal to allow blood flow around the catheter so the hypertonic fluid is diluted in the flowing blood.

Intravenous fluids can be administered using gravity feed and counting the drops through an administration set. This can be harder to maintain a steady flow rate with alterations in limb position for example. When shock rates of fluids are being administered a pressure bag can help increase the flow rate. More commonly a fluid pump is used that can deliver a steady rate of fluids under pressure. The most common types are a peristaltic pump or a cassette style pump. The peristaltic pumps administer fluids at a more constant rate, but the cassette style pumps are more accurate over time.

There are a number of potential complications of intravenous catheters. These can include infection, thrombophlebitis, extravasation of fluids, air embolism, overhydration, impaired fluid delivery because of a bent leg, or even exsanguination. These can all be minimized by careful catheter placement and monitoring. Care should be exercised when removing catheters to ensure the catheter is not cut with resultant catheter embolism.

**Subcutaneous**

The subcutaneous route can be an alternative for administration of maintenance fluids in dogs and cats, but is not suitable in more seriously dehydrated patients as absorption will likely be delayed by peripheral vasoconstriction. Potassium can be added as long as the concentration is less than about 30 mmol/L. Typically the fluids are administered over the back, and up to 10 ml/kg per site. Subcutaneous fluids may be a way for owners to administer fluids at home. Overhydration is rare unless the patient is in heart failure. Irritating solutions or hypertonic solutions should not be administered via this route.

**Intrapertitoneal**

Whilst moderate volumes of fluids can be administered via this route, it is not routinely recommended. Absorption rates are variable, there is a risk of infection, and only isotonic fluids should be used.

**Intraosseous**

This route is primarily used in very young or very small animals where intravenous access is difficult. The bone marrow cavity is not affected by vascular collapse. There is rapid venous access via the bone marrow sinusoids and medullary venous channels. A bone marrow aspirate style needle can be used, or in very young animals a spinal needle or hypodermic needle may be used. Some local anaesthetic should be placed over the site of insertion
down to the periosteum. Suitable sites include the tibial tuberosity, wing of the ilium, trochanteric fossa of the femur, or the greater tubercle of the humerus. Fluid rates administered can be similar to intravenous access, and some drugs can also be administered via this route.

**Oral**

The oral route is not suitable for animals with acute or serious fluid loss as the absorption and dispersion of the fluids occurs too slowly. It is also not a suitable route of fluid administration when there is gastrointestinal dysfunction. Some advantages include the ability to administer large volumes of fluid, hypertonic fluid, or material with a high caloric density to meet caloric requirements. In some settings it can be a long term solution for fluid administration, for example renal failure cats may have hydration maintained at home via oesophagostomy tubes.

**Rate and Volume of Fluid Administration**

The rate of fluid administration will depend on the amount and rate of fluid loss. For animals in shock the rate of administration will be high. In dogs a shock rate is considered to be 90 ml/kg, and in cats is 40 – 60 ml/kg. These rates can be administered over an hour. It is important to closely monitor the patient for response to the fluids, by monitoring vital signs, blood pressure etc. For example 25 – 50% of this volume may be administered over 30 minutes, and then the patient is reassessed. In patients with less pressing deficits the decision is made based on clinical signs of how rapidly to replace fluid deficits, and this may be over anywhere from 6 hours to 24 hours. In some situations such as diabetic ketoacidosis care must be taken to not replace deficits too rapidly. Ongoing losses should be taken into account as well when determining the rate of fluid administration, so for example in a patient with severe gastrointestinal disease the fluid rate may be higher. The fluid rate may vary depending on concurrent disease states. Animals with cardiac disease may require lower fluid rates for example. Surgical or anaesthetic procedure fluid rates vary from 5 – 10 ml/kg/hour.

When calculating the volume of fluid the goals of the fluid therapy are correction of fluid deficits, replacement of ongoing losses and providing daily fluid needs. The fluid deficit can be calculated using the percentage dehydration and body weight (percentage dehydration x body weight). The resultant figure is the deficit in kg. Ongoing losses can be difficult to estimate, but measurement of vomiting or diarrhoea (by weighing incontinence pads lining a cage for example), or recording the volume of effusions drained can help in this endeavour. Maintenance rates can vary from patient to patient, but are often estimated to be between 40 – 60 ml/kg/day. The values for replacement, ongoing losses and maintenance should be added together and an hourly rate calculated.

**Monitoring Fluid Therapy**

It is essential to monitor patients receiving fluid therapy closely. As discussed the figures used to determine fluid requirements for replacement, ongoing losses and maintenance are all estimates, so monitoring can help determine if the fluid rate being administered is adequate or not, or potentially excessive.

Patients receiving fluids should be examined twice daily, including vital signs and assessment of hydration, and examination of the cervical area to check for jugular venous distension. Body weight should be included as part of this evaluation. Blood pressure should also be assessed. Urine output should also be assessed. In patients that are critical, or in potential acute renal failure patients this can be quantified with the placement of an indwelling urinary catheter and closed collection system.
Laboratory assessment should include once to twice daily measurement of PCV/TP, and electrolytes. If possible the acid base status should also be evaluated. Urine specific gravity can also be evaluated, and if the patient is adequately hydrated the urine should be isosthenuric.

The assessment of central venous pressure can help assess whether fluid therapy is adequate or excessive. This requires a central venous line, with a jugular catheter at the level of the right atrium. A progressive increase in the CVP above reference range in a patient on fluids suggests overhydration is likely, and a sudden rise may suggest the patient is at risk of pulmonary oedema.

Clinical signs of overhydration may include serous nasal discharge, conjunctival swelling, tachycardia, tachypnoea, dyspnoea, cough, jugular venous distension, restlessness and pulmonary crackles on auscultation. If these occur fluid therapy should be stopped.

**When to Stop Fluids**

The fluids can typically be stopped when the patient has a normal hydration status, and the cause of the illness has resolved to a degree that recurrent dehydration is unlikely. Ideally the patient should be able to maintain normal fluid balance through oral intake of fluids. In some acute diseases the fluids can be stopped from a maintenance rate without tapering. In some diseases such as renal failure it is better to taper the fluids slowly, but 25-50% per day to avoid complications.

**Use of Synthetic Colloids**

Whilst fluid extravasation from blood vessels is influenced by a number of factors, the two primary ones are intravascular colloid osmotic pressure and capillary hydrostatic pressure. The theory of using synthetic colloids is that given their larger molecular size they are retained in the vasculature to a greater degree than crystalloid fluids. As a result a smaller volume of a colloid solution results in greater expansion of the plasma volume when compared to crystalloid fluids. The duration of plasma volume expansion with colloid solutions varies with a number of factors including the species of the patient, dose used, the colloid solution chosen and microvascular permeability.

The colloid solutions are polydisperse, in that they contain molecules of variable molecular weights. The effect of the colloid on colloid osmotic pressure (COP) is related to the number of molecules rather than their size. The smaller molecules contribute significantly to the COP, but they are cleared from the circulation in a matter of hours. The intravascular colloid concentration will still remain elevated because of the larger molecules however, but the number rather than the size of the particles is of primary importance.

There are three main types of synthetic colloid solutions available, based on how they are synthesized – hydroxyethyl starches (HES), dextrans and gelatins. The hydroxyethyl starches are synthesized by partial hydrolysis of amylopectin, the dextrans from a macromolecular polysaccharide that is a bacterial fermentation product of sucrose, and the gelatins from hydrolysis of bovine collagen.

The molecules in the HES solutions are usually quite variable in size, but the solutions can be generally divided into high, medium or low molecular weight solutions based on the average molecular weight. The weight average molecular weight can be calculated from light scattering of the solution.
Colloids are primarily used to expand intravascular volume in patients suffering hypovolaemic or distributive shock. Given the variable molecular weight of the particles, it is always essential to carefully monitor the response to synthetic colloid therapy. The recommended dose in dogs is 20 ml/kg/day, which is approximately one quarter of a blood volume. Cats are more susceptible to volume overload than dogs and the dosage recommended is 5 ml/kg.

Care must be taken with the use of synthetic colloid solutions in cases of pulmonary oedema. This may be the result of increased hydrostatic pressure or increased vascular permeability. The pulmonary vasculature is relatively permeable to protein and it equilibrates more rapidly with the interstitial space. Colloid therapy may well worsen pulmonary oedema associated with increased vascular permeability. Because clearance of macromolecules from the alveolar space is very slow, this may potentially be life threatening. Even in cases of pulmonary oedema associated with increased hydrostatic pressure colloids must be used with care because of the risk of the induction of volume overload.

The use of synthetic colloids in patients with severe hypoproteinaemia may be indicated. If peripheral oedema is associated with hypoalbuminaemia the synthetic colloids may help. If large ongoing losses are present they may be less effective, and diagnosis and therapy of the underlying disease is essential.

Synthetic colloids may have effects on laboratory tests. There may be a reduction in the total protein on a refractometer due to osmotic shifts of fluid into the vascular space after administration. Values on a complete blood count and biochemical profile may also reduce as a result of a dilutional effect.

There are potential adverse effects when using synthetic colloids in practice. They appear to have adverse effects on both primary and secondary haemostasis. The mechanisms are not completely understood, but are likely multifactorial. The colloids may impair the action of endothelial adhesion molecules, with resultant reduced endothelial release of von Willebrand’s factor. HES molecules may also bind to vWF and factor VIII hastening their elimination. Platelet dysfunction may result because HES molecules may coat their surface and interfere with their binding to ligands. Volume overload can occur with the use of colloids, and the risks are greater in patients with cardiac disease, pulmonary disease, or oliguria/anuria. Anaphylaxis is a rare complication of the use of the synthetic colloids.

**Blood Transfusions**

Blood and blood products have a number of indications in practice. Red cell transfusions are used to increase oxygen carrying capacity, whereas plasma can be used for oncotic support, volume expansion, or provision of clotting factors. It is important to remember that the transfusion of blood products is not without risk, such as volume overload, transmission of infection, and immunological reactions. Blood products are less readily available than crystalloid or synthetic colloid solutions, and the costs are significantly higher.

Blood products can be obtained in house. For most practices this will entail the use of whole blood collected from an in house donor. Few practices have the equipment to separate whole blood into packed red blood cells and plasma, so will use the whole blood. The use of whole blood is often less efficient – consider a unit of whole blood collected could have packed cells used for an anaemic patient and the fresh frozen plasma utilized for a patient with a coagulopathy. An alternative to in house collection of whole blood is the purchase of blood products from a blood bank such as that at the University of Melbourne.
In banked blood there will often be packed red blood cells and fresh frozen plasma produced. From 450 ml blood collected there will often be around 200 ml of packed red blood cells. Fresh frozen plasma is produced when the harvested plasma is frozen within eight hours of collection. This will contain clotting factors which can be preserved for twelve months if stored at -30 degrees C, or six months at -20 degrees C. Cryoprecipitate can be produced by partially thawing fresh frozen plasma and removing the white precipitate that forms – this is rich in von Willebrand’s factor, fibrinogen, and factors VIII and XIII. Platelet rich plasma is rarely used in veterinary medicine.

If using donors in a practice setting ideally the blood donors should be typed. Seven canine blood type systems have been recognized, but typing is only available for five of these. Whilst there is not universal agreement on the ideal blood types for donors, they should ideally be negative for DEA (Dog Erythrocyte Antigen) 1.1, 1.2 and 7. In cats there are type A, B and AB recognized. A new, common red cell antigen called Mik has been identified. In contrast to dogs there can be naturally occurring alloantibodies, and in Type B cats given Type A blood there can be severe (and potentially fatal) reactions even in cats that have not received a prior transfusion. There is a relatively high incidence of Type B domestic cats in Australia. Donors should also ideally be screened for infectious diseases. In Australia canine donors should be vaccinated and be Dirofilaria negative, and if in an area where Babesia infections occur they should also be screened for infection. Cats should test negative for FIV and FeLV, and also for feline haemotropic Mycoplasma.

In dogs because of the low rate of preformed alloantibodies an initial transfusion without cross-matching is often undertaken. Ideally DEA 1.1 positive blood would not be given to a DEA 1.1 negative recipient to avoid sensitizing the dog. Crossmatching should be performed for subsequent transfusions however. In cats cross matching is preferable. Blood typing can prevent the transfusion of Type A blood to a type B cat and vice versa, but will not identify the Mik antigen.

Blood products should always be administered through a filtered administration set to remove any debris and blood clots that form during storage of the products. In cats where blood is bring administered using a syringe driver an in-line filter can be employed. Blood products are most commonly administered intravenously, but the intra-osseous route is also an alternative. If administering crystalloid fluids concurrently 0.9% NaCl should be used.

The volume of product infused is variable. For administration of whole blood in dogs a starting point is 10-22 ml/kg, whereas for packed red blood cells 6-10 ml/kg is a guideline. In cats the volume of blood administered may be up to 50 ml. In dogs the volume of whole blood or packed red cells to be administered can be calculated using the following formula

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\text{Volume transfused} = 90 \text{ ml x body weight (kg)} \times \left[ \frac{\text{Desired PCV-Patient PCV}}{\text{PCV of donor blood}} \right]
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For plasma in dogs the recommended starting dosage for coagulopathies is 6-10 ml/kg, and coagulation assays can be monitored to assess the efficacy of therapy.

Unless the patient is a neonate, blood or packed red cells do not typically require warming before administration. Fresh frozen plasma can be thawed at room temperature, or if it needs to be thawed more quickly it can be placed in a ziplock bag and placed in a 37 degree C water bath. Blood and plasma should be administered within a four hour period to avoid bacterial growth. If large amounts of blood or plasma are being administered within 24 hours the serum potassium, calcium, and magnesium concentrations should be monitored, and coagulation studies potentially performed.
Adverse reactions are possible with blood transfusions. Acute haemolytic transfusion reactions are possible, and occur rapidly, and may be irreversible and fatal. For example in a Type B cat given Type A blood there may be fever, vomiting, lethargy, icterus and death. A rapidly declining PCV would be noted along with an increasing bilirubin concentration. Dogs may show signs of fever, restlessness, hypersalivation, and vomiting. Haemoglobinuria and haemoglobinuria may develop acutely. In some cases there may be non haelytic fever and urticaria. Delayed haemolysis may occur in some patients 7-10 days post transfusion. Other potential complications can include transmission of infection. As mentioned previously if large volumes of blood are transfused there can be hyperkalaemia, hypocalcaemia or hypomagnesaemia.

In cases where the patient has hypovolaemic shock as a result of haemorrhage

**Recommended Reading**


