

# Companion animal fluid therapy part 2: planning and monitoring

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[Part one of this article \(VT46.35\)](#) introduced fluid therapy, fluid dynamics and the variety of fluid types available. Such knowledge is a prerequisite to safely and effectively develop fluid therapy plans, which are discussed in this part.

## Approaches to fluid therapy

Table 1. Clinical findings that can indicate the degree of dehydration present	
Estimated degree of dehydration	Clinical signs
Lower than 5%	Not detectable.
5-6%	<ul style="list-style-type: none"><li>● Subtle loss of skin elasticity.</li><li>● Possibly tacky mucous membranes.</li></ul>
6-10%	<ul style="list-style-type: none"><li>● Decreased skin turgor and delay in return of skin to normal position.</li><li>● Possibly retracted eyes within orbits.</li><li>● Dry mucous membranes.</li></ul>
10-12%	<ul style="list-style-type: none"><li>● Persistent skin tent.</li><li>● Eyes retracted within orbits.</li><li>● Dull corneas.</li><li>● Evidence of hypovolaemia.</li></ul>
12-15%	<ul style="list-style-type: none"><li>● Signs of hypovolaemic shock, such as tachycardia and weak pulses.</li><li>● Death.</li></ul>

**Table 1.** Clinical findings that can indicate the degree of dehydration present.

Animals may require fluid therapy for numerous reasons, including restoration of intravascular volume, correction of dehydration, treatment of electrolyte disturbances (beyond the scope of this article) or simply when the animal is not able to match its daily fluid requirements with adequate food and/or water intake.

When devising a fluid therapy plan, consider the following questions (DiBartola and Bateman, 2012):

- Does the animal need fluid therapy?
- What type of fluid needs to be given?
- What route of administration should be used?
- How much fluid should be given?
- How rapidly should the fluid be given?
- When should fluid therapy be discontinued?

## Assessment of fluid therapy requirement

A thorough history and clinical assessment is a critical starting point to determine how much and what type of fluid is required. An accurate history can provide clues to the chronicity of the process, along with the type of body fluid lost. A detailed clinical examination – especially of the cardiovascular, respiratory and neurological systems – is vital.

Fluid loss can manifest as either hypovolaemia or dehydration. This depends on both the speed of fluid loss and the compartment the fluid has been lost from:

- Hypovolaemia – reduced intravascular volume occurring with plasma water or whole blood loss.
- Dehydration – a water deficit associated with all fluid compartments, thus causing an overall increase in electrolyte concentrations.

Clinical signs of hypovolaemia	Mild (compensated)	Severe (decompensated)
Heart rate	Mild tachycardia	Severe tachycardia (inappropriate bradycardia in cats)
Mucous membrane colour	Normal to pinker, then normal	White, grey or muddy
Capillary refill time	Normal (less than one second)	Prolonged (more than two seconds or absent)
Pulse amplitude	Increased	Decreased
Ease of palpation of metatarsal pulse	Easy (more difficult in cats)	Absent
Mentation	Often normal	Depressed
Plasma lactate concentration	3mmol/L to 5mmol/L	More than 8mmol/L

**Table 2.** Clinical findings that can indicate the severity of hypovolaemia present.

These two states cause different clinical signs. It is important to be able to differentiate between dehydration (**Table 1**; Goggs et al, 2008) and hypovolaemia (**Table 2**; Boag and Hughes, 2007) as the treatment plan will vary.

A patient with acute, severe hypovolaemia may present in shock. In these situations it is critical to differentiate hypovolaemic shock from cardiogenic shock (Goggs et al, 2008), which occurs due to cardiac pump failure. The fluid required for restoration of intravascular volume in hypovolaemic shock can be potentially fatal in cardiogenic shock. Discrimination between the two can be made by a patient's history, signalment and clinical findings (presence of pulmonary oedema, for example).

## Fluid therapy required

Panel 1. Example of potassium addition. The details of additives should always be written on the fluid bag, as this will often be specific for the individual patient. It also helps prevent inadvertent fluid boluses from potassium-supplemented fluids being administered

- Body mass of dog: 25kg.
- Required infusion rate of fluids: 4ml/kg/hr.
- Serum potassium level: 2.3mmol/L.
- Amount of potassium to add to 250ml NaCl: 15mmol.
- Fluid type required: Hartmann's solution.
- Amount of potassium contained in Hartmann's solution: 5mmol/L.
- Size of fluid bag: 1,000ml.
- Total amount of potassium to add: 55mmol (15mmol per 250ml = 60mmol per 1,000ml - 5mmol/L contained in Hartmann's solution).
- Concentration of potassium solution: 13mmol per 5ml  
? 2.6mmol/ml.
- Volume of potassium to be added to fluid bag: 21.15ml.
- Final concentration of potassium in fluids: 60mmol/L  
? 0.06mmol/ml.
- Infusion rate of fluids: 100ml/hr.
- Total potassium infused per kg, per hour: 0.24mmol/kg/hr (this is a safe infusion rate of the potassium containing fluids, as it is below the stipulated 0.5mmol/kg/hr).

Different fluid types were considered in detail in part one of this article. Broadly speaking, most patients requiring fluid therapy can be managed with a small selection of crystalloid solutions and additives (DiBartola and Bateman, 2012). The most useful are balanced extracellular fluid replacers, which have a composition similar to plasma (see **Table 4** from part one).

The most commonly used commercially available solution in the UK is Hartmann's solution, with Plasma-Lyte being more common in the US.

As discussed in part one, even these solutions are not ideal for prolonged use. Compared to an animal's electrolyte maintenance requirement, they are low in potassium and high in sodium and

chloride. This can result in hypokalaemia with a concurrent hyperchloraemic metabolic acidosis. Vets often rely on a patient's kidneys to resolve any iatrogenic disturbances, although this could become a problem in those with compromised renal function.

Colloids are usually reserved for use in one of three situations.

- Cases of hypoproteinaemia (most commonly hypoalbuminaemia) when colloid osmotic pressure (COP) is reduced. Use of colloidal solutions in this situation can boost COP, aiding with maintenance of intravascular fluid.
- When rapid intravascular expansion is required, particularly when large volumes of fluids passing into the interstitium (causing oedema) may be contraindicated. Colloid solutions do not redistribute as rapidly, so give more effective intravascular volume expansion for a smaller volume administered compared to crystalloid solutions.
- When a longer duration of effect is required (compared to crystalloid solutions, which rapidly redistribute).

Although, in most cases, use of balanced extracellular fluid replacers is suitable, the vet should aim to replace losses with a fluid similar in volume and electrolyte composition to that lost (DiBartola and Bateman, 2012).

One rare example of a clinical indication for administration of a solution other than a balanced electrolyte crystalloid is persistent vomiting. Such patients lose stomach hydrochloric acid through vomiting, as well as potassium and water from lack of intake. Metabolic alkalosis may also occur due to the loss of acid. Potassium-supplemented 0.9 per cent NaCl will help replace that lost. Administration of 0.9 per cent NaCl also has a mild acidifying effect.

## Additives

<b>Table 3. Amount of supplemented potassium required depending on serum potassium levels. Absolute rate of potassium administration should not exceed 0.5mmol/kg/hr</b>	
Serum potassium (mmol/l)	Amount of potassium to add to 250ml 0.9 per cent NaCl (mmol)
Lower than 2	20
2-2.5	15
2.5-3	10
3-3.5	7
3.5-5.5	5 (minimum daily need in anorectic patients)

**Table 3.** Amount of supplemented potassium required depending on serum potassium levels.

Absolute rate of potassium administration should not exceed 0.5mmol/kg/hr.

As many commercially available fluids do not fit the exact specifications required, it is common to add other substances before administration. The most common additive is potassium chloride (KCl). Many hospitalised patients are hypokalaemic, either as a direct result of underlying disease processes, anorexia or fluid therapy.

Addition of KCl helps counteract the severity of hypokalaemia, which may ensue with mid-to-long-term use of the commonly used extracellular fluid replacers. Be aware, however, addition of KCl will also increase the chloride concentration, potentially making any concurrent hyperchloraemia worse.

The *BSAVA Small Animal Formulary* (Ramsey, 2014) provides useful guidelines for the amount of supplemented KCl required depending on the patient's serum potassium (**Table 3**; Ramsey, 2014; **Panel 1**). When calculating fluid rates, care must be taken that a safe rate of IV potassium administration is adhered to. Rates in excess of 0.5mmol/kg/hr can be fatal, with additional caution recommended when the potassium concentration in replacement fluids is more than 60mmol/L. Where possible, it is recommended infusion pumps are used to ensure administration rates are accurate.

As KCl has a relatively higher density than most commercially available fluids, it is essential to thoroughly mix the bag, once KCl is added, before it is connected to the animal.

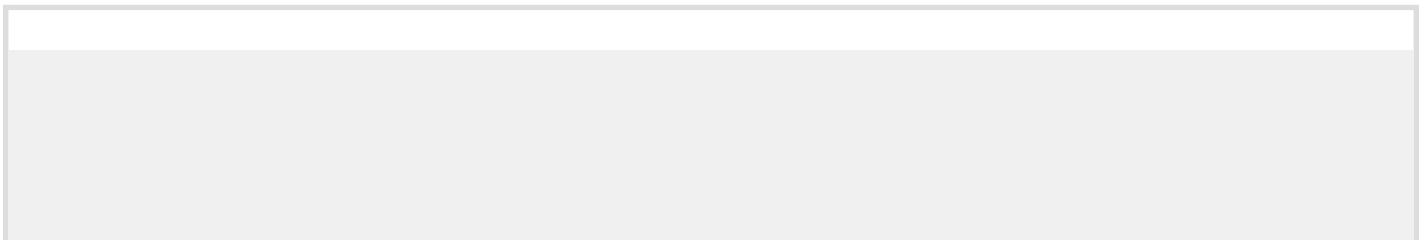
Other additives are used, less commonly, depending on specific requirements. These may include (DiBartola and Bateman, 2012):

- 50% dextrose
- calcium chloride or gluconate
- (potassium) phosphate

## Routes of administration

Numerous routes are available for fluid administration and some thought should be given as to how best to achieve the desired effect.

### Intravenously







**Figure 1.** Figure 1. The most common way to provide fluid therapy is via the IV route. A number of sites for IV cannula placement are commonly used. The cannula needs to be placed in an aseptic manner after appropriate fur clipping and skin cleaning. A light dressing is commonly applied over the cannula to ensure cleanliness and discourage patient interference. Although usually well tolerated, patients will occasionally require an Elizabethan collar.

Arguably the most practical and effective route is intravenously. Immediate deposition within the intravascular space allows for rapid expansion, with further redistribution depending on individual fluid dynamics.

IV administration is most commonly achieved through placement of a peripheral vein cannula, such as the cephalic, lateral or medial saphenous (**Figure 1**). In chondrodysplastic species, or those with large ears (such as basset hounds and dachshunds), the marginal auricular veins are an alternative. Care should be taken with cannula placement at this site in rabbits, as it is anecdotally reported thrombosis and subsequent skin sloughing can occur.

In large animals, such as horses, a centrally positioned cannula (such as jugular) is often used. This site is an option for small animals, if a long-stay cannula is required.

Cannulas should be placed in an aseptic manner with appropriate clipping and skin preparation. In emergency situations do not permit this, cannulas should be replaced in an aseptic manner as soon as is practical. Placement of wider bore, shorter cannulas allow the most rapid fluid flow. A simple dressing offers protection for the cannula, although this should be replaced at least once daily. This allows inspection for any signs of inflammation, thrombosis or perivascular fluid administration. All IV cannulas should be flushed every four hours if continuous fluid therapy is not being used (Davis et al, 2013).

## **Intraosseous**

In neonates and other small patients, venous access can be difficult to establish. In such patients, intraosseous fluid administration is an alternative – a needle, such as a 20G spinal needle, is inserted into the medullary cavity of a long bone.

Possible sites include the femur, tibia, humerus or wing of the ilium.

Studies have shown uptake via this route to be comparable to IV (Cameron et al, 1989). As for IV cannulas, the skin should be prepared aseptically prior to needle placement. It is recommended intraosseous cannulas remain in situ no longer than 72 hours. After removal, the same bone should not be reused, as fluids may leak out of the original hole into the surrounding tissue.

## **Intraperitoneal**

Fluids can be administered directly into the peritoneal cavity, where they are absorbed into the circulation via the peritoneum and portal circulation (Lukas et al, 1971). A bolus of isotonic crystalloid solution can be administered off the needle. However, it is not considered to be suitable for emergency acute volume replacement as associated vasoconstriction does not allow absorption (McNamara et al, 1993).

## **Subcutaneous**

The SC route is included for completeness; however, it is not considered to be appropriate for rapid large-quantity volume replacement. During severe hypovolaemia, SC tissue perfusion is much reduced, so absorption from this site is slowed.

However, for mild dehydration, or to help prevent losses, this route may still be used (Davis et al, 2013). Only isotonic crystalloids should be used and the volume administered is limited by the SC space.

## **Gastrointestinal tract**

If healthy, the gastrointestinal tract is a useful route to supply fluids. However, its use in an acute



hypovolaemic state is limited. The gastrointestinal tract is best used for situations of mild dehydration or fluid volume disturbances, often in an outpatient setting (Davis et al, 2013).

## Amount and speed of fluid administration



**Figure 2.** A paediatric giving set with burette. A restricted volume of fluid can be released via a roller clamp from the fluid bag into the burette. The flow from the burette can be controlled by a second roller clamp distal in the burette. These deliver 60drops/ml and, as such, are more accurate than the usual adult 20 drops/ml giving sets. This makes them potentially safer for smaller patients or those at risk of fluid overload. Image: Asher Allison.

Determination of a patient's fluid needs requires an initial clinical examination and ongoing monitoring of response to treatment.

The basic aims of fluid therapy are to:

- replace fluid deficits
- supply daily fluid needs
- supply ongoing fluid losses

As a general rule, any fluid deficit should be replaced over a time scale similar to that it was lost at, either acutely or over a day or more.

The exact amount of fluids required to replace deficits and supply daily needs and ongoing losses

can be highly variable and individualised. It needs to take into account any sensible (easy to measure, such as urine output) and insensible (difficult to measure, such as respiratory and faecal) fluid losses.

Although an oversimplification with extrapolation from human medicine, a rough guide for fluid rates in various situations is given in **Table 4**.

### **‘Maintenance’ fluid rates**

“Maintenance” fluid rates are the subject of debate, but for dogs, these are quoted to be between 40ml/kg/day to 60ml/kg/day (1.6ml/kg/day to 2.5ml/kg/day).

Generally speaking, smaller patients require a rate at the top end of the range, while large patients are towards the lower end (DiBartola and Bateman, 2012). Due to their higher body water content, neonatal animals also require a greater “maintenance” fluid rate (Macintire, 2008; Davis et al, 2013).

### **Anaesthetic fluid rates**

Traditionally, it was stated anaesthetic fluid rates were 10ml/kg/hr, although a growing body of evidence in human and veterinary medicine suggests this may be detrimental, particularly in healthy patients (Brodbelt et al, 2007; Boscan et al, 2010).

Guidelines suggest rates lower than 10ml/kg/hr, with starting rates of 3ml/kg/hr and 5ml/kg/hr for cats and dogs, respectively (Davis et al, 2013). This can be increased if needs dictate during the anaesthetic.

### **Fluid requirement for dehydration**

A patient presenting with dehydration should have the degree of dehydration estimated (**Table 1**) and subsequent equivalent volume of fluid calculated based on its body mass.

For example, a 10kg dog estimated to be 10 per cent dehydrated would require 1.0L of fluids to replace this deficit (**Table 4**). This needs to be added to daily maintenance and estimated ongoing losses (due to continued vomiting/diarrhoea) replaced over the next 24 to 48 hours.

### **Acute hypovolaemia and shock**

Traditionally, it was proposed “shock doses” of fluids for treatment of acute hypovolaemia consisted of one circulating blood volume given as an isotonic crystalloid bolus; around 60ml/kg and 90ml/kg for cats and dogs respectively (Hopper et al, 2012). However, a more conservative approach is recommended, using approximately 20 per cent of this volume as a rapid IV bolus,

followed by reassessment. If necessary, this can be repeated until normal cardiovascular parameters are restored and maintained.



**Figure 3.** Although relatively expensive to purchase, syringe drivers and fluid infusion pumps ensure volumes of fluids are given in an accurate and consistent manner.

However, one study demonstrated volume replacement in hypotensive dogs did not reliably decrease heart rate, despite increases in blood pressure (Silverstein et al, 2012). In some instances, hypertonic solutions with or without colloids may be chosen to replace intravascular volume, particularly in larger patients, as replacement can be achieved more rapidly with a smaller total volume (Schertel et al, 1997).

## Administration

The most common way to administer fluids is through the use of an adjustable rate giving set, with gravity assisting flow. The desired fluid rate is calculated by knowledge of fluid volume per drop and counting the number of drops in the chamber per second.

The two most common types of giving sets are standard “adult” sets, which administer 20 drops/ml of fluid, and “paediatric” burettes, which administer 60 drops/ml of fluid (**Figure 2**).

Burettes have the advantage that fluid administration can be more accurate and a smaller volume of fluid can be stored. This limits the risk of fluid overload in small patients if the rate inadvertently exceeds that intended. If large volumes of fluid are required to be administered very rapidly (such as volume resuscitation for a patient with gastric dilatation-volvulus), a pressure bag can be placed over the fluid bag and inflated to a pressure above systolic arterial pressure.

Although perfectly acceptable, the use of gravity-assisted, free-flow fluids can sometimes be inaccurate, for example, due to changes in patient position. The use of either syringe drivers (small

volumes) or fluid pumps (large volumes) can greatly improve accuracy and consistency of fluid delivery (**Figure 3**).

## Monitoring fluid therapy

Although the suggested rates in **Table 4** are a useful starting point, repeated patient assessment must be performed and rates adjusted accordingly so as to not administer excessive volumes. Fluid therapy is a pharmacological intervention, with administration having potential adverse effects, including peripheral and pulmonary oedema (Cornelius et al, 1978; Bjorling and Rawlings, 1983).

Table 4. Suggested fluid rates for a variety of situations. These are intended only as a starting point and may require adjustments for individual patients	
Scenario	Fluid rate
"Maintenance" crystalloid fluid requirement	<ul style="list-style-type: none"> <li>● Adult – approximately 2ml/kg/hr.</li> <li>● Neonate – 3ml/kg/hr to 5ml/kg/hr.</li> </ul>
General anaesthesia	<ul style="list-style-type: none"> <li>● Dog – 5ml/kg/hr to 10ml/kg/hr.</li> <li>● Cat – 3ml/kg/hr to 10ml/kg/hr.</li> </ul>
Dehydration	Daily "maintenance" rate and estimated ongoing losses plus deficit (administered over 24 to 48 hours): Fluid deficit (L) = body mass (kg) × percentage of dehydration (as a decimal).
Acute hypovolaemia (isotonic crystalloids)	<ul style="list-style-type: none"> <li>● 10ml/kg to 20ml/kg as a rapid IV bolus.</li> <li>● Reassessment of cardiovascular parameters on completion may dictate that repeated doses are required.</li> </ul>
Acute hypovolaemia (colloids)	<ul style="list-style-type: none"> <li>● 2ml/kg to 5ml/kg as a rapid IV bolus.</li> <li>● Reassessment of cardiovascular parameters on completion may dictate that repeated doses are required.</li> </ul>

**Table 4.** Suggested fluid rates for a variety of situations. These are intended only as a starting point and may require adjustments for individual patients.

Cats are particularly prone to fluid overload due to their smaller blood volume and higher incidence of occult heart disease (Paige et al, 2009) and, therefore, close monitoring of feline patients is imperative. Variables that can be used to monitor fluid therapy, avoiding such adverse effects, include the following.

### Physical examination

Physical examination includes assessment of the cardiorespiratory system that may indicate ongoing dehydration and/or hypovolaemia (**Tables 1 and 2**). A good thoracic auscultation is important to detect signs that may indicate pulmonary oedema.

Regular monitoring of a patient's body mass over the hospitalisation period can give indications of fluid accumulation (Boscan et al, 2010). A gain or loss of 1kg can be considered equivalent to 1.0L of fluid, as lean body mass does not alter rapidly (DiBartola and Bateman, 2012).

However, one study indicated estimation of dehydration was not predictive of weight change after fluid therapy (Hansen and DeFrancesco, 2002). The frequency of assessment will depend, to some degree, on the aggressiveness of fluid therapy, but should ideally be at least twice daily.

## Laboratory findings



**Figure 4.** A central venous pressure (CVP) manometer set up in a kennel. The open-ended manometer is connected via a three-way tap to a fluid infusion (such as 0.9 per cent NaCl), which is, in turn, connected to a jugular catheter in the patient. The zero mark on the manometer needs to be level with the patient's right atrium for accurate measurement. When the fluid filled manometer is opened, via the three-way tap to the patient's jugular vein, the fluid level will read the mean CVP value. As CVP may become negative, especially during inspiration, a length of the manometer must be positioned below the level of the patient's right atrium.

Serial measurements of haematocrit, total protein and lactate can provide useful indicators to the

efficacy of fluid therapy. Trends in lactate can be useful during acute intravascular volume replacement (Zacher et al, 2010; Green et al, 2011), although an initial rise in plasma lactate concentration after commencing volume resuscitation may be seen due to improved perfusion washing out accumulated tissue lactate.

## **Urine output**

Measurement of urine output can offer some indications as to the effectiveness of fluid therapy, although it may be influenced by additional factors, such as anaesthesia and the stress response.

A dehydrated or hypovolaemic patient is expected to have reduced urinary output, but this should resolve (with a concurrent decrease in urine-specific gravity) as a patient is rehydrated. Normal urine output is 1ml/kg/hr to 2ml/kg/hr. If oliguria persists, despite volume expansion, renal function may be compromised and further increases in administered fluid volume may result in pulmonary oedema (DiBartola and Bateman, 2012).

## **Central venous pressure**

Use of central venous pressure (**Figure 4**), particularly during a fluid challenge, can provide a crude indication to a patient's fluid status. However, this is not often used in first opinion practice due to the necessity of a jugular catheter. Discussion of its use is beyond the scope of this article.

## **When to discontinue fluid therapy**

Fluid therapy can be discontinued when deficits have been replaced and the animal is eating and drinking sufficiently to meet its maintenance requirements. In practice, it is often sensible to taper the volume of fluid administered over a day or more (depending on the chronicity of treatment).

If a patient is anorexic after two to three days' treatment, it is worth considering parenteral nutrition or, providing the gastrointestinal tract is functional, placement of a feeding tube such as an oesophagostomy tube.

## **Conclusions**

Provision of fluid therapy, like many pharmacological interventions, needs to be an individualised process determined by thorough and continued patient assessment.

Although, in practice, the variety of fluid types described in part one of this article may not be available, a basic knowledge of these can help the clinician determine the best solution for the patient from what is accessible. Dose or infusion rates may need periodic adjustments to maximise the benefits gained while minimising potential adverse effects associated with fluid administration.

- [Practical fluid therapy in companion animals – part 1](#)

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