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Review Article

Understanding fluid therapy in canine and feline medicine: A comprehensive guide

S. N. Yadav[1*], N. Ahmed[2] and P. K. Boro[1]

[1]Department of Veterinary Medicine, Lakhimpur College of Veterinary Science, Joyhing, Assam Agricultural University, North Lakhimpur- 787 051, Assam, India; [2]Department of ARGO, Lakhimpur College of Veterinary Science, Joyhing, Assam Agricultural University, North Lakhimpur- 787 051, Assam, India

Abstract

Fluid therapy is a medical procedure that aims to replenish bodily fluids lost due to illness. Its origins can be traced back to 1832, when Thomas Latta first introduced it to help patients suffering from cholera. The specific type and quantity of fluids administered depend on various factors, including hydration levels, electrolyte balance, stability, and availability. However, studies indicate that critically ill patients may experience adverse effects if administered improperly. Therefore, it is crucial to carefully consider the timing, fluid selection, and administration method to achieve the best possible outcome.

Keywords: Canine, Dehydration, Feline, Fluid, Management

Highlights

- Fluid therapy replaces lost bodily fluids.
- The amount and type of fluids given depend on different factors.
- Prognosis in critically ill patient is poor if fluid therapy is improper.
- Proper knowledge of different fluid compartments is necessary.

INTRODUCTION

Fluid therapy is replenishing body fluid loss in any pathological condition. In 1832, Thomas Latta described the first intravenous administration of salt-based solutions for cholera patients (Stanzani and Chan, 2014). Since then, intravenous fluid administration has become the ubiquitous symptomatic treatment for human and veterinary practices. It has become the most common therapeutic protocol and is a gateway to the care of companion animals with abnormal fluid disturbances. The selection of a fluid type and its dose is based on the availability, patient's hydration status, electrolyte balance, and hemodynamic stability (Lyons and Waddell, 2018). Despite ubiquitous use, side effects of fluid therapy are also suggested in human medicine research (Stanzani and Chan, 2014). Research into fluid therapy contributes to the poor prognosis of critically ill patients (Londono, 2019). Human research may guide the veterinary community to assess existing fluid therapy procedures and guidelines focused solely on scientific rather than clinical facts. This article reviews the four Ws of fluid therapy, *viz.* why are fluids essential, when to administer fluids, what are the routes for its success, and which type to administer.

Normal fluid physiology

To comprehend fluid therapy and its uses, fluid and water circulation through the body must first be known. Total body water (TBW) is around 60% of the animal's lean body weight in adults (Burton and Hoper, 2019) and 80% in paediatric animals (Lyons and Waddell, 2018). TBW is distributed in the intracellular compartment (approximately 66%) and as extracellular fluid (ECF) (approximately 33%) (Stanzani and Chan, 2014) (Fig. 1). The cell membrane splits these two compartments. The extracellular fluid (ECF) is distributed into three spaces: intravascular (approximately 21.37% of ECF) (approximately 8% and 6.5% of TBW in dogs and cats, respectively) (Tello and Perez-Freytes, 2017), interstitial space (approximately 75% ECF) (Mazzaferro and Powell, 2013), and transcellular fluid (approximately 3.67% ECF) (Seifter and Chang, 2017). In response to osmotic forces, water freely passes cell membranes, allowing overall solute amounts (osmolality) to be the same across all compartments (Maffly and Leaf, 1959). To preserve cell size and for normal function, the body retains osmolality within a tight range. Any fluid loss from any compartment must be replaced by fluid from the other above compartment. Osmolality is controlled

*Corresponding Author, E-mail: sampurna.n.yadav@aau.ac.in

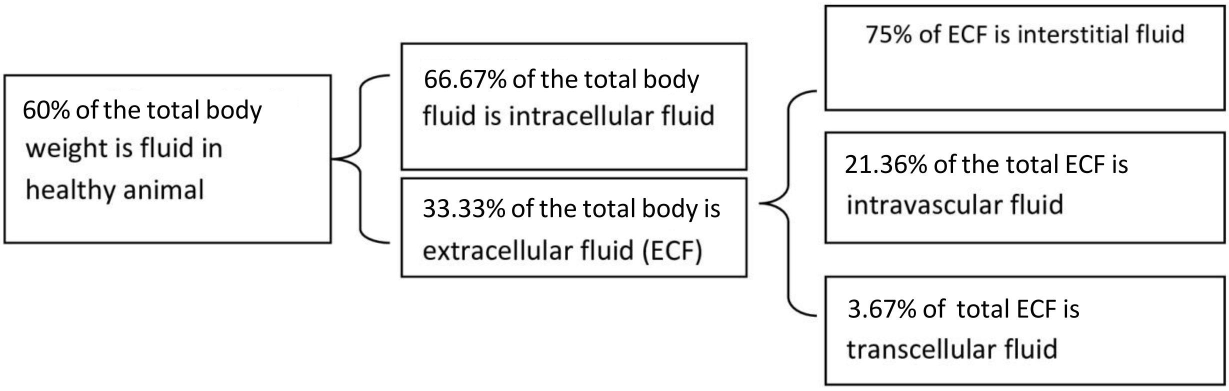

Fig. 1. Diagrammatic representation of fluid in different compartments of body in percentage

primarily by water intake, i.e., thirst or retention or excretion of water by the kidney (Burton and Hoper, 2019).

Fluid loss disturbances warranting fluid therapy, as outlined by Davis *et al.* (2013), encompass changes in volume, alterations in content, and shifts in distribution within the body.

Change in fluid volume (dehydration from any cause, blood loss, heart disease)

Dehydration is a state of excessive fluid loss in the interstitial and intracellular compartments of a living organism (Kavouras, 2019), whereas hypovolemia explains intravascular fluid shortages (Lyons and Waddell, 2018). Hypovolemia can occur with or without dehydration (Davis *et al*., 2013). Two terms related to it and provide a deep understanding of it are a) Osmolality, which is a measure of the total solid present in the solution (Yadav *et al*., 2020), and b) Tonicity, which refers to the effective solutes in a solution (Lyons and Waddell, 2018). Different etiologies of dehydration and its findings are described below. Hypovolemia is usually induced by extreme dehydration, the rapid loss of fluid (gastrointestinal loss, blood, polyuria), and vasodilatation. There are symptoms of reduced tissue perfusion in hypovolemic patients, such as irregular mentation, altered mucous membrane colour, abnormal capillary refill duration, decreased pulse strength, abnormal pulse rate, and/or cold extremity (Davis *et al*., 2013). Hyperthermia is also one of the causes of dehydration. Dehydration can be isotonic, hypotonic, or hypertonic in canine and feline.

Isotonic/isonatremic dehydration: Water and salt loss together. Vomiting and diarrhoea usually result in isotonic fluid loss, serum sodium concentration, chloride concentration, and osmolality within the usual reference range (Tello and Perez-Freytes, 2017). If the animal drinks water, hyponatremia could arise from hypotonic replacement therapy (Lyons and Waddell, 2018). It is characterized by tiredness, no thirst, a ring around the eyes, wrinkles in the skin, weak and fast pulse, and frequent kidney failure.

Hypertonic/hypernatremic dehydration: Extra-cellular fluid loss is more than salt loss. Diabetes insipidus, pulmonary losses due to hyperventilation and temperature, and diarrhoea result in hypotonic fluid loss (Lyons and Waddell, 2018). Serum sodium, chloride, and osmolality are high. Severe thirst, mucous membrane and tongue dryness, neurological symptoms, generalized impairment, and fever characterize it.

Hypotonic/hyponatremic dehydration: Extracellular fluid loss is less than salt loss, which is uncommon. However, it can be seen in hypoadrenocorticism, secretary diarrhoea, vomiting, and third space (such as peritoneal and pleural) fluid loss and diuretic administrations (Lyons and Waddell, 2018). Serum sodium, chloride, and osmolality are lost. It is characterized by nausea, loss of appetite, convulsion, moist tongue, and third sensation loss.

Change in fluid content

Patients with body fluid composition variation include electrolyte abnormalities, blood glucose variation, anaemia, and polycythemia. Specific electrolyte imbalances in cats and dogs include hypo and hyperkalemia, hypo and hypernatremia, hypoproteinemia/hypoalbuminemia, and hypo and hyperglycemia (Davis *et al*., 2013).

Change in fluid distribution

Fluid distribution disorders include different edema types (interstitial, peripheral, and pulmonary and patients with effusion (skin burn, pleural, and abdominal). The primary causes for both these conditions are loss of vascular integrity and decreased intravascular oncotic pressure.

Fluid deficit determination

Assessment of dehydration is necessary for determination of fluid deficit in a body. Intracellular dehydration cannot be identified through physical assessment; it is mainly assessed by changes in sodium concentration. The dehydrated individuals have some hypovolemia; clinical changes do not occur until dehydration reaches 10% (Lyons and Waddell, 2018). The minimum fluid depletion percentage recorded on physical examination is 5%, and dehydration may be fatal over 12% (Rudloff, 2015; Lyons and Waddell, 2018). Several basic assessments can be used to determine hydration status. One of the simplest to do is to measure the turgor or the skin's moisture. The skin is pulled over the thorax or lumbar area for turgor examination. The skin returns to its usual resting place with a well-hydrated animal (Macintire and Haskins, 2005; De Brito Galvao and Centre, 2006). If the tent is built, it can be an indicator of dehydration. The authors attempt to combine the skin turgor test, percentage of dehydration, and physical findings in Table 1, showing different subjective findings on the different percentages of dehydration. As per the authors' suggestion, regardless of hydration status, emaciated and old-age animals develop decreased turgor, obesity increases turgor, and normal turgor in very young animals. These conditions will confound the skin tent trial and be considered concerning other physical testing criteria and outcomes. Another way for dehydration assessment is to feel for moistness on the mucous membranes. This is more conveniently achieved by slipping a finger around or within a patient's gum border. Dehydration may occur if the membranes are dry or sticky (Hughston, 2016). In vomiting pets, residual saliva must be distinguished from mucous membrane moisture in the mouth. In individuals with normal renal function, oliguria may indicate dehydration and concentrate the small amount of urine produced (Macintire and Haskins, 2005).

Other laboratory examinations that help to assess fluid deficits are packed cell volume, total protein, serum sodium, serum potassium, and glucose. USG and PCV / TP will help the veterinary staff assess fluid resuscitation activity's success since all quantities are predicted to decline after the intravascular volume has recovered. Interstitial fluid and ICF compartments are replenished.

Haemoconcentration (high PCV) and hyperproteinemia (high TP) are observed in dehydrated patients as the body seeks to preserve fluid equilibrium and homeostasis, leading to a depletion of the blood fluid component (Hughston, 2016). Hypovolemia due to decreased oncotic pressure is presumed when total protein in patients is <35 g/L or albumin <15 g/L (Di Bartola, 2012). Furthermore, hypovolemia can occur in shock patients, characterized by decreased blood pressure and raised lactate (2 mmol/L) (Pang and Boysen, 2007).

Fluid deficit calculation

Fluid loss considerations are an essential aspect of the fluid therapy strategy. Fluid losses may have existed before clinic presentation — such as in animals with a record of persistent vomiting or diarrhoea- or may be expected during care, as is frequently found in post-obstructive diuresis in urinary obstructed cats (Hughston, 2016). These losses must be considered when determining the type of fluid therapy, amount, and route. Veterinarians should include urination, defecation, diarrhoea, vomiting, the expulsion of effusions or gastrointestinal contents, leakage of blood and insignificant losses (such as panting) (Hughston, 2016).

Fluid requirement

In the emergency phase of veterinary care, determining the fluid requirement is crucial, especially

Table 1. Subjective assessment of dehydration (%) based on physical findings and skin turgor (Robinson, 2016; Lyons and Waddell, 2018)

Dehydration (%)	Skin turgor (Time to return to normal)	Physical findings
0-5	<2 sec	Not detectable
5-8	2-4 sec	Eyes slightly sunken in sockets; mucous membrane slightly dry or tacky
8-10	5-10 sec	Eyes sunken in sockets; mucous membrane dry, slightly tacky
10-12	10-30 sec	Eyes very sunken; dry mucous membrane; animal is depressed; sign of shock (hypovolemia)
>12	>30 sec	Hypovolemia shock; death

considering factors like body weight and percentage of dehydration. According to Davis *et al*. (2013), the formula for calculating the volume required to correct dehydration is body weight (kg) multiplied by the percentage of dehydration. Maintenance fluid rates, as suggested by Davis *et al.* (2013), follow thumb rules for cats (80 x body weight (kg) 0.75 per 24 hours) and dogs (132 x body weight (kg) 0.75 per 24 hours), with recommended hourly rates of 2-3 mL/kg/hr for cats and 2-6 mL/kg/hr for dogs. Schaer (2005) emphasizes that, considering insensitive fluid loss and assuming standard urine output, the maintenance fluid requirement for pets is typically 50 to 60 mL/kg/day.

When correcting dehydration, Davis *et al.* (2013) highlight the importance of considering existing and current fluid losses along with maintenance volumes. Current deficits should be replaced within 2-3 hours, while existing volume losses may be replaced over a more extended duration. The standard goal is to rectify dehydration within 24 hours, though certain conditions, such as cardiac disease, may impose limitations. Monitoring frequency, typically ranging from 15 to 60 minutes, depends on the extent of resuscitation delivered. Regular assessment of euhydration is essential to avoid fluid overload. Additionally, caution is advised against using maintenance solutions low in Na to replace extracellular deficiencies, as these solutions may contribute to hyponatremia and hyperkalemia when administered in significant volumes.

Route of fluid administration

The four main fluid distribution routes are intravenous (IV), intraosseous, subcutaneous (SC), and oral. The intraperitoneal route can also be used (Hughston, 2016). Schaer (2005) reported that intraosseous and intravenous routes are best for critically ill patients as they provide direct access to intravascular space. For hospitalized patients, IV fluid administration is usually chosen since, based on medical needs, the distribution rate may be managed and adjusted easily (Lyons and Waddel, 2018). As reviewed by Schaer (2005), a comparison of the different routes of fluid administration is shown in Table 2.

Table 2. Comparison of different fluid routes in canine and feline (Schaer, 2005)

Route	Indications	Procedure	Advantages	Limitations
Oral	Anorectic pet with mild, short-term diseases	1. Stomach tube, 2. Pharyngostomy tube, 3. Small dosing syringe, 4. Small baby bottle and nipple considering the animal size	1. Preferred route for small animal less than 20 kg body weight, 2. Preferred for neonates	1. Aspiration pneumonia, 2. Not beneficial in hypovolaemic shock, 3. Never be used in vomiting animal
Subcutaneous	1. For correction of mild to moderate dehydration, 2. Conducive for pet weighing more than 10 kg body weight	1. Only isotonic fluids should be used, 2. The best way for this route is by gravity flow with 18 to 20 gauze (Adult pet) and smaller gauze needle (Paediatric), 3 No more than 10-12 mL/kg/ site to be administered, 4. Fluid must be deposited dorsally along the region bordered anteriorly by scapulae and posteriorly by iliac crests	For maintenance of patients who are not too critically ill	1. Avoid using fluids that are hypertonic and hypotonic, 2. Avoid using fluid under devitalized skin and contaminated skin, 3. Not useful for hypovolemic patient
Intraperitoneal	When intravenous route is not possible for medium and	1. Only use isotonic fluids,2. Needle of gauze 16-20, depending on the size of patient	1. Sufficient amount of fluid over a short period, 2. Relatively fast	1. Dehydration can deteriorate with hypertonic fluid, 2. It should be voided

Cont. Table 2.

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Route	Indications	Procedure	Advantages	Limitations
	large size breed	should be used, 3. Infusion site is lateral to the midline and midway between the umbilicus and pelvic brim	absorption	in patients with abdominal sepsis, ascites or peritonitis,3. Do not use in the patient pending for abdominal surgery,
Intravenous	1. Severe dehydration and hypovolemia, 2. Most effective	Needle or cannula insertion should be performed in a sterile condition, and hygienic condition should be maintained throughout the process	1. Best route for correcting hypotension, 2. Provides quick and accurate fluid delivery	1. Fluid overload, 2. Catheter sepsis and phlebitis,
Intraosseous	1. Intravenous access is not possible, 2. Primarily useful in small size patients	1. One cm distal to tibial tuberosity, proximal media tibia, or the trochanteric fossa of femur are common sites, 2. 18-20 gauze hypodermic needle, a spinal needle or a small bone marrow needle is inserted with a small nick incision		

Oral route: The oral route is the easiest route of fluid therapy, which can resolve certain conditions (mild salt toxicity and dehydration). It can be accomplished by giving the patient a pre-calculated water bowl at frequent intervals and calculating the quantity drunk. However, for pets with gastrointestinal pathology (i.e., parvovirus infection), vomiting, or those unable to drink sufficient water volume to sustain regular urinary output or create and maintain fluid homeostasis, other fluid resuscitation strategies may be utilized.

Subcutaneous route: It is anticipated to prevent losses and is non-suggestive for replacement therapy except for mild dehydration and mild water deficit or assist the patient with chronic disease. The pet attendant can be trained to administer it as it is easy to administer. This route should be used only for isotonic crystalloids. Dextrose, hypotonic (i.e., D5W), or hypertonic solutions should not be administered through this route (Davis *et al*., 2013) as extracellular electrolyte diffuses the concentration gradient into the infusion area. As this occurs, the resulting drop in plasma solute will reduce the amount of circulating blood and induce hypotension (Schaer, 2005).

Intravenous route: It is the preferred route for severely dehydrated and medium to large pets. The intravenous route allows clinicians to quickly adapt to patients' changing needs. This route requires the insertion of a cannula/scalp vein into the vein using a sterile technique. This technique's success mainly depends on the knowledge of the requirement of fluid and other complications associated with it. Common complications are phlebitis, catheter sepsis, fluid overload, and fluid flow into the surrounding subcutaneous tissue. If a cannula is used, it should be replaced with a new one every 72 hours (Schaer, 2005) to prevent iatrogenic complications.

Intraosseous route: A preferred route for a pet weighing less than 5 kg (Schaer, 2005) is when the intravenous approach is impossible in a patient with burn and edema. Bone marrow has direct access to systemic circulation, and through intraosseous route, most of the medication can be administered safely and efficaciously. (Orlowski *et al*., 1989).

Fluid selection

Different types of fluid are available as shown in

Table 3 with some having specific indications. An attempt is made to classify the fluid based on its type and use.

Table 3. Common crystalloid and colloid solutions available for canines and felines, including their osmolality (Di Bartola, 2012)

Solution	Osmolality (mOsm/L)
Crystalloid solutions	
Lactated Ringer's	273
0.9% saline (Normal Saline)	308
0.45% saline (Half Normal Saline)	154
5% dextrose in water (D5W)	252
Plasma-Lyte A	294
Normosol-R	294
Colloid solutions	
Hydroxyethyl starch (Hetastarch)	310
VetStarch	310
Dextran 70	310
Gelatin-based solutions	274
Albumin (Human)	300-320

Crystalloids: This fluid type contains small solutes (smaller than 500 Da) (Lyons and Waddell, 2018), primarily electrolytes and occasionally molecules such as glucose or lactate. Due to the small size of its solutes, these solutions freely cross the capillary wall, and more than 60 to 80% distribute out of intravascular space within 20 to 30 minutes (Smith, 2017; Lyon and Waddell, 2018). Crystalloid fluids based on their tonicity concerning plasma, i.e., 270 mOsm/L to 320 mOsm/L in dogs and cats (Debra and Deborah, 2015), can be classified as isotonic, hypotonic and hypertonic (Barlow *et al*., 2020).

As per the author's view, most veterinarians are familiar with isotonic fluid, whereas they significantly less commonly use hypotonic or hypertonic fluid. Considering the severe consequences of hypotonic and hypertonic fluid, it is suggested that they should be labelled and kept separately from isotonic fluid.

Isotonic fluid: It has the effective osmolality as the extracellular fluid (approximately 270 to 310 mOsm/L). It has a sodium concentration similar to that of extracellular fluid, having little effect on intracellular volume (Rudloff and Hopper, 2021). The electrolyte content and Ph of isotonic fluid closely resemble plasma. These solutions have an advantage over other solutions for maintenance as they can administered through all the routes mentioned above except oral. Isotonic fluid is commonly used to treat hypovolemia and intestinal dehydration since fluid losses are mostly isotonic or hypotonic (Lyons and Waddell, 2018). An isotonic solution like 0.9% normal saline or physiological saline, Ringer's, lactated Ringer's, acetated Ringer's, and 2.5% dextrose in 0.45% saline are commonly used (Schaer, 2005).

0.9% normal saline or physiological saline (310 mOsm/L) commonly used for rehydration. Since it has the supraphysiological value of sodium and chloride ions (154 mEq/L), it is not recommended for maintenance. It can be primarily used for volume expansion, for treating metabolic alkalosis along with potassium chloride supplementation, and for treating hyponatremia. The lack of buffering capacity of 0.9% normal saline infusion can be complicated by metabolic acidosis. After plasma volume restoration, it should not be used in a patient with congestive heart failure (Tonog and Lakhkar, 2019) or any condition restricting sodium use.

Ringer's solution (309 mOsm/L) is a type of isotonic solution. The potassium and calcium concentration of Ringer's solution is nearly equal to blood and extracellular fluid, but potassium concentration is supraphysiologic (155 mEq/L). Potassium and calcium should be advised additionally to this fluid if deficiency is observed (Schaer, 2005).

Lactated ringer's solution (LRS) (273 mOsm/L) (Singh *et al*., 2021) is an isotonic solution comprised of polyions. LRS is more physiologic than isotonic saline as it's electrolyte content mimics that of plasma. Lactate ions of LRS get converted to bicarbonate in the patient's liver, reversing metabolic acidosis. Thus, it should never be used in patients with existing metabolic or respiratory alkalosis (Schaer, 2005). LRS use should be limited in patients with hepatic dysfunction and diabetic ketoacidosis, as lactate cannot be converted to bicarbonate (Lyons and Waddell, 2018). Each liter of LRS contains four mEq of potassium, and its supplementation is advised in patients with hypokalemia. It is commonly used as a rehydrating solution, maintenance solution, and plasma expander, and it is a superior choice for acidotic animals.

Acetated Ringer's solution (ARS) (295 mOsm/L) is a crystalloid solution with similar use and restriction as LRS. ARS is preferable to LRS in a patient with hepatic disorders, as ARS is metabolized in the muscle and other peripheral tissue (Schaer, 2005). Another advantage of ARS in shock patients is that it uses less oxygen for its metabolism to carbon dioxide and bicarbonate ions. Including Magnesium in ARS (Semler and Kellum, 2019) makes it a better choice for patients with concurrent hypomagnesemia.

Dextrose 2.5% in 0.45% saline is almost isotonic (280 mOsm/L). In dehydrated patients, after the rehydration and normal electrolyte restoration, it is the choice of fluid for maintenance when combined with potassium chloride supplementation. In an azotemic cat with urethral obstruction where sodium intake is restricted, and patients tend to develop hypernatremia with normal saline, it is the fluid of choice (Schaer, 2005).

Hypotonic solution: This solution has a lower concentration of sodium ions (Na+) and chloride ions (Cl-) (Robinson, 2016). It has less effective osmolality than ECF and plasma (Vujovic *et al.*, 2018). This redistributes all fluid compartments, with most going into intracellular space. This enables water replenishment and maintenance (Robinson, 2016). As they are ineffective at increasing intravascular volume and may result in cerebral edema from intracellular fluid shifting, hypotonic solutions are inappropriate for bolus therapy. When administered directly, hypotonic solutions cause haemolysis by moving water into erythrocytes. Hence, several hypotonic solutions contain dextrose. Thus, isotonic solutions are used initially. Rapidly metabolized dextrose leaves a hypotonic solution. Even though these solutions generally provide intracellular hydration, they are often unsuitable for maintenance electrolyte needs because sodium and chloride are often provided in surplus with insufficient potassium.

Hypotonic crystalloids treat patients with hypotonic fluid losses resulting in hypernatremia or patients with renal disease who cannot excrete the salt from balanced isotonic solutions (Lyons and Waddell, 2018).

Hence, it is suggested that maintenance fluid requirements should be provided through feed as far as possible. Examples of hypotonic solutions are i) 5% dextrose solution in water (D-5-W, 253 mOsm/L), ii) 2.5% dextrose solution (D-2.5-W, 126 mOsm/L), iii) 0.45% sodium chloride solution (155 mOsm/L).

D-5-W: This solution is used in i) patients with hypernatremia, ii) as a carbohydrate source, and iii) as a fluid of choice for patients with sodium intolerance. It should not be the only intravenous therapy as it can cause hyponatremia, hypochloremia, hypokalemia and hypomagnesemia. D-5-W should never be used for the correction of extracellular fluid deficit correction since 66% of the infused fluid volume will migrate to intracellular space within the first hour of infusion (Schaer, 2005). On the other hand, isotonic solution is present in extracellular space for longer duration of time.

Hypertonic solution: It is important to note that hypertonic saline solutions have a greater osmolality than plasma and extracellular fluid (Schaer, 2005). One commonly used hypertonic solution is dextrose 5% in 0.9% saline, which has an osmolality of 560 mOsm/L. While it can help to maintain fluid balance in fully rehydrated patients, it should be administered slowly through an IV and never used in dehydrated animals. In well-hydrated, hyponatremic patients, it can provide energy and sodium supplementation.

Studies have suggested that small-volume hypertonic saline solution (7.5%) can effectively initiate resuscitation from hemorrhagic shock (Garvey, 1989). Administering 4 to 5 mL/kg of sodium chloride 7.5% (2400 mOsm/L) can rapidly increase blood pressure and cardiac output and promote elevated renal, total splanchnic, and coronary blood flow. This treatment can lead to vasodilation, increased myocardial contractility, and fluid redistribution from the extravascular to the intravascular compartments, causing a transient rise in circulating volume.

Colloid solution: Colloid solutions are comprised of large molecules, typically exceeding 10,000 Da, and they remain in the intravascular space for an extended period, surpassing that of crystalloids (Cazzolli and Prittie, 2015; Liu and Silverstein, 2015). Hydroxyethyl starch (HES) is the most frequently utilized colloid solution for hypovolemia. While some extravasation may occur, the colloid remains in the intravascular space, allowing for its efficacy. The duration of colloids' half-life varies depending on their molecular structure. Administering a colloid does not draw interstitial water into the intravascular space. However, it does act against filtration out of the intravascular space, as there is no absorption at the venules. Overhydration symptoms include increased skin turgor, peripheral edema, pleural effusion, pulmonary edema, serous nasal discharge, and chemosis. HES treatment has been controversial, with some research pointing to an increased risk of acute kidney injury (AKI) and mortality in humans. The Food and Drug Administration has issued a "black box" warning for HES. A study on dogs receiving a 10% HES solution showed an increased risk of AKI and death. Other potential adverse reactions to HES include coagulopathy, pruritus, reticuloendothelial dysfunction, proinflammatory effects, volume overload, hepatopathy, and anaphylaxis. Nonetheless, further investigation is necessary to determine the risk-to-benefit ratio in animal patient populations. Our institution uses HES with caution.

Other colloids in treatment include fresh or frozen plasma, canine albumin, and human serum albumin. Plasma is particularly beneficial as it contains coagulation factors and albumin. However, since the albumin concentration is comparable to plasma, administering large quantities is necessary to have an oncotic effect. For instance, injecting around 40 to 50 mL/kg can raise serum albumin levels by 1g/dL. Ideally, species-specific albumin would be preferred, but it is costly and only sporadically available. For dogs with hypoalbuminemia, concentrated human serum albumin can be used. However, an immediate or delayed hypersensitivity reaction is possible due to its non-homologous nature with canine albumin. Immediate reactions are more common in healthy individuals, whereas critically ill patients who receive human serum albumin may experience delayed hypersensitivity as a significant complication.

Conclusion

A comprehensive examination of fluid therapy in veterinary medicine is necessary for those looking to provide the best possible care to their animal patients. This includes a thorough understanding of the various types of fluids available, the indications for their use, and the potential complications that can arise. By staying up-to-date with the latest research and guidelines, veterinary professionals can ensure they provide their patients with the most effective and safe fluid therapy. With proper attention to detail and a commitment to excellence, veterinarians and animal healthcare providers can help ensure their patients receive the best possible care.

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Author's contribution: SNY: Conceptualized and designed the review; SNY, NA, PKB: Drafted the manuscript, collected the literature, edited and finalized the manuscript. All the authors read and approved the manuscript.

REFERENCES

Barlow A, Barlow B, Tang N, Bhavik MS and Amber EK, 2020. Intravenous fluid management in critically ill adults: A Review. Crit Care Nurse, 40(6): e17-e27, doi: 10.4037/ccn2020337

Burton AG and Hopper K, 2019. Hyponatremia in dogs and cats. J Vet Emerg Crit Care, 29: 461-471, doi: 10.1111/vec.12881

Cazzolli D and Prittie J, 2015. The crystalloid-colloid debate: consequences of resuscitation fluid selection in veterinary critical care. J Vet Emerg Crit Care, 25(1): 6-19, doi: 10.1111/vec.12281

Davis H, Jensen T, Johnson A, Knowles P, Meyer R *et al.*, 2013. Fluid therapy guidelines for dogs and cats. J Am Anim Hosp Assoc, 49(3): 149-159, doi: 10.5326/JAAHA-MS-5868

Debra TL and Deborah CS, 2015. Crystalloids, colloids, and hemoglobin-based oxygen-carrying solutions. In Small Animal Critical Care Medicine (Deborah CS, K Hopper, eds) W.B. Saunders, pp 311-316, doi: 10.1016/B978-1-4557-0306-7.000581

De Brito Galvao JF and Center SA, 2006. Fluid, electrolyte, and acid-base disturbances in liver disease. In: Fluid, Electrolyte and Acid-Base Disorders in Small Animal Practice (Di Bartola SP, Balteman S), 3rd edn. St Louis, MO: Saunder Elsevier

Di Bartola SP, 2012. Fluid, Electrolyte, and Acid-base Disorders in Small Animal Practice. 4th edn. St. Louis (MO): Elsevier Saunders; 2012

Garvey MS, 1989. Fluid and electrolyte balance in critical patients. Vet Clin North Am Small Anim Pract, 19(6): 1021-1057, doi: 10.1016/s0195-5616(89)50127-x

Hughston L, 2016. The Basic of Fluid Therapy for Small Animal Veterinary Technician. Available: https://todaysveterinarynurse.com/articles/the-basics-of-fluid-therapy-for-small-animal-veterinary-technicians/ (Accessed on 30 November 2023)

Kavouras SA, 2019. Hydration, underhydration, optimal hydration: are we barking the wrong tree? Eur J Nutr, 58: 471-473, doi: 10.1007/s00394-018-01889-z

Liu DT and Silverstein DC, 2015. Crystalloids, colloids, and hemoglobin-based oxygen carrying solutions. (Silverstein D, Hopper L, eds). Small Animal Critical Care Medicine. St. Louis, MO: Elsevier. pp 311-315, doi: 10.1016/B978-1-4557-0306-7.00058-1

Londono L, 2019. Fluid Therapy in Critical Care. Available: https://todaysveterinarypractice.com/fluid-therapy-in-critical-care/ (Accessed on 30 November 2023)

Lyons BM and Waddell LS, 2018. Fluid Therapy in Hospitalized Patients, Part 1: Patient Assessment and Fluid Choices. Available: https://todaysveterinarypractice.com/fluid-therapy-part-1fluid-therapy-hospitalized-patients-patient-assessment-fluid-choices/ (Accessed on 28 November 2023)

Macintire DK and Haskins SC, 2005. Manual of Small Animal Emergency and Critical Care Medicine. 2nd edn. Philadephia, PA: Lippincott Williams and Wilkins

Maffly RH and Leaf A, 1959. The potential of water in mammalian tissues. J Gen Physiol, 42(6): 1257-1275, doi: 10.1085/jgp.42.6.1257

Mazzaferro E and Powell LL, 2013. Fluid therapy for the emergent small animal patient: crystalloids, colloids, and albumin products. Vet Clin North Am Small Anim Pract, 43(4): 721-734, doi: 10.1016/j.cvsm.2013.03.003

Orlowski JP, Julius CJ, Petras RE, Porembka DT and

Gallagher JM, 1989. The safety of intraosseous infusions: risks of fat and bone marrow emboli to the lungs. Ann Emerg Med, 18: 1062-1067, doi: 10.1016/s0196-0644(89)80932-1

Pang DS and Boysen S, 2007. Lactate in veterinary critical care: pathophysiology and management. J Am Anim Hosp Assoc, 43(5): 270-279, doi: 10.5326/0430270

Robinson R, 2016. Available at https://www.vettimes.co.uk/article/companion-animal-fluid-therapy-part-2-planning-and-monitoring/ (Accessed on 30 November 2023)

Rudloff E and Hopper K, 2021. Crystalloid and colloid compositions and their impact. Front Vet Sci, 8: 639848, doi: 10.3389/fvets.2021.639848

Rudloff E, 2015. Assessment of hydration. In: Silverstein D, Hopper K, editors. Small Animal Critical Care Medicine, 2nd edn. St. Louis. MO: Elsevier

Schaer M, 2005. Fluid Therapy for Critically III Dogs and Cats. Avialable:https://www.vin.com/apputil/content/defaultadv1.aspx?pId=11196&id=3854241&print=1 (Accessed on 30 November 2023)

Seifter JL and Chang H, 2017. Extracellular acid-base balance and ion transport between body fluid compartments. Physiology, 32(5): 367-379, doi: 10.1152/physiol.00007.2017

Semler MW and Kellum JA, 2019. Balanced crystalloid solutions. Am J Respir Crit Care Med, 199(8): 952-960, doi: 10.1164/rccm.201809-1677CI

Singh S, Kerndt CC and Davis D, 2021. Ringer's Lactate. [Updated 2021 Sep 2]. In: Stat Pearls [Internet]. Treasure Island (FL): Stat Pearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK500033

Smith L, 2017. Choosing between colloids and crystalloids for IV infusion. Nursing Time (Online), 113(12): 20-23

Stanzani G and Chan DL, 2014. Controversies in fluid therapy. Eur J Companion Anim Pract, 24(2): 14-23

Tello L and Perez-Freytes R, 2017. Fluid and electrolyte therapy during vomiting and diarrhea. Vet Clin North Am Small Anim Pract, 47(2): 505-519, doi: 10.1016/j.cvsm.2016.09.013

Tonog P and Lakhkar AD, 2019. Normal Saline. In: Stat Pearls. Stat Pearls Publishing, Treasure Island (FL)

Vujovic P, Chirillo M and Silverthorn DU, 2018. Learning (by) osmosis: An approach to teaching osmolarity and tonicity. Adv Physiol Educ, 42(4): 626-635, doi: 10.1152/advan.00094.2018

Yadav SN, Ahmed N, Nath AJ, Mahanta D and Kalita MK, 2020. Urinalysis in dog and cat: A review. Vet World, 13(10): 2133-2141, doi: 10.14202/vetworld.2020.2133-2141

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