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Fluid and Electrolyte Therapy During Vomiting and Diarrhea



Luis Tello, DMV, MS, DVM^{a,*}, Rossana Perez-Freytes, DVM, MPH^b

KEYWORDS

• Dehydration • Vomiting • Diarrhea • Fluid therapy • Small animals • Gastroenteritis

KEY POINTS

- Fluid therapy is the most important therapeutic measure in a pet suffering from dehydration caused by gastrointestinal losses (vomiting and diarrhea).
- Fluid therapy should be tailored to the patient's history, presenting complaint, physical examination, and laboratory findings; it is specific to the patient's needs and is modified based on the physical and laboratory findings until fluid therapy resuscitation end points are achieved.
- The selection of fluid replacement should be determined by serum electrolytes and blood gas analysis.

INTRODUCTION

The 2014 the Pet Health Report from Banfield Pet Hospital¹ summarized a comprehensive meta-analysis of a veterinary population consisting of 2.3 million dogs and approximately 470,000 cats. This health report provided information that revealed gastrointestinal consultations as the main reason for large breed dogs to visit the veterinary office in 2014. From this report, it could also be clearly appreciated that gastroenteritis represents an average of 4% of all canine cases that present to the veterinary hospital on any given day with colitis or large bowel diarrhea representing between 3% and 6% of the working diagnoses.

VOMITING

Vomiting is a complex reflex that leads to the forceful expulsion of stomach contents through the mouth and requires the coordination of the gastrointestinal, musculoskeletal,

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^a Health and Education Center 2, Hannah the Pet Society, 10164 SW Washington Square Road #B3, Tigard, OR 97223, USA; ^b Veterinary Healthcare Associates, 3025 Dundee Road, Winter Haven, FL 33884, USA

* Corresponding author.

E-mail address: drluistello@gmail.com

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and nervous systems. Many structures are involved in the vomiting process. These include the emetic center located in the reticular formation of the medulla oblongata, the chemoreceptor trigger zone located on the floor of the fourth ventricle within the brain, and the vagal and sympathetic neurons stimulated by receptors in the abdominal viscera.² Activation of the vomiting reflex can occur for many reasons. These include local or systemic inflammation, irritation, distention, hypertonicity, emetogenic substances including toxins and medications (eg, apomorphine, nonsteroidal anti-inflammatory drugs, some antineoplastic agents), and impulses that arise from the vestibular center because of motion sickness.³

The color of vomitus helps the clinician identify its origin. Clear vomitus constitutes swallowed saliva from the stomach, yellow represents reflux of digested bile from the stomach, and green coloration suggests undigested bile originating from the upper duodenum caused by an obstruction or ileus. A brown fluid with a fetid odor is most likely from the small intestines and suggests a total obstruction or generalized ileus. In the case of primary gastrointestinal disease, the presence of blood in the vomitus typically appears as a red-tinged fluid or as “coffee grounds.” Streaks or flecks of blood within clear vomitus may come from gastric or esophageal irritation and is not of specific pathology.⁴

Patients that present for vomiting display a wide constellation of clinical signs that vary from vague to pathognomic for a particular condition or etiology (**Box 1**). The diagnostic dilemma is to unveil the inciting cause, treat and correct it, while at the same time treating all secondary complications related to the vomiting. In cats, vomiting is a particularly common and complex problem. Adult cats often have different and more chronic causes of vomiting than kittens. Nonetheless, the condition remains a common reason for cats to be presented for veterinary care.⁵ In domestic cats, vomiting is caused by primary gastrointestinal diseases and extragastrointestinal diseases. Examples of primary disease include infectious, inflammatory, parasitic, obstructive (foreign body, trichobezoar, worm impaction), drug-related, or nutritional. Extragastrointestinal causes include endocrinopathies (eg, hyperthyroidism); metabolic disease (eg, renal failure); inflammatory diseases; and other disease processes, such as hepatopathy, pancreatitis, or neoplasia (especially alimentary lymphoma). This wide spectrum of potential causes of vomiting in cats increases the difficulty for the practitioner in making a definitive diagnosis.⁶

DIARRHEA

Diarrhea is the result of excess fecal water that may be from decreased intestinal absorption, increased intestinal secretion, or both. Most cases of diarrhea are mild and self-limiting requiring minimal diagnostic testing and symptomatic care, but for more severe cases, diagnostic testing and intensive therapy are warranted (**Box 2**). Small intestinal diarrhea typically results in a larger fecal volume and fluid, electrolyte, and protein loss, and acid-base abnormalities. Large bowel diarrhea is characterized by small volume, multiple defecations, with feces of a soft consistency, and the presence of mucus or fresh blood. Tenesmus may or may not be present. It is important to differentiate small bowel versus large bowel because it has a significant impact on the diagnostic and treatment plan. Most commonly, the duration of the diarrhea is subjectively classified as acute (<14 days) or chronic (>14 days). The mechanism of diarrhea in the feline and canine patient is divided into four subcategories and these can occur alone or in any combination: (1) secretory diarrhea, (2) osmotic diarrhea, (3) increased intestinal permeability, and (4) abnormal gastrointestinal motility.^{7,8} Secretory diarrhea results when there is a disturbance to the ion pumps in the gastrointestinal epithelium

Box 1**Common causes of vomiting in dogs and cats***Abdominal, Alimentary Disorders*

- Infections bacterial, fungal, viral
- Inflammation: gastritis, enteritis, gastroenteritis, pancreatitis
- Neoplasia
- Toxicity
- Obstruction
- Ulceration
- Intussusception
- Foreign bodies
- Motility disorders

Metabolic disorders

- Uremia
- Liver failure
- Electrolyte disorders
- Acid-base disorders

Systemic Disorders

- Sepsis
- Endotoxemia
- Multiple organ failure

Exogenous Medications

- Erythromycin and other antibiotics
- Chemotherapy drugs
- Apomorphine
- α_2 -Agonists: xylazine, medetomidine, dexmedetomidine
- Nonsteroidal anti-inflammatory drugs: ketoprofen, meloxicam, carprofen

Other Abdominal Disorders

- Septic peritonitis
- Uroperitoneo
- Pyometra
- Hemoperitoneo
- Dietary indiscretion
- Food hypersensitivity reactions

Endocrine Disorders

- Diabetes mellitus (ketoacidosis)
- Hyperthyroidism
- Hypoadrenocorticism

Nervous System Disorders

- Encephalitis/meningitis

- Hydrocephalus

Toxicity

- Ethylene glycol
- Heavy metals (copper, zinc, lead)
- Strychnine

caused by bacterial endotoxins. When there is compromise to the gastrointestinal mucosa from gastrointestinal mucosal erosions (eg, severe shock, toxins, hyperthermia, foreign body) or blunting of villi (eg, viral or bacterial pathogenic agents) there is fluid loss. Diarrhea can occur via any or all of these mechanisms. For example, the presence of cellular debris in the intestinal lumen contributes to osmotic diarrhea, hypomotility results in ileus and increased permeability, and endotoxins represent ion pump inhibitors resulting in secretory diarrhea. The presence of frank red blood (hematochezia) or black tarry stool (melena) should alert the clinician that there is a disruption to the integrity of the gastrointestinal epithelium and protein loss, and bacterial translocation should be anticipated. In conclusion, the gastrointestinal patient suffers from malaise and anorexia that decreases water and caloric intake, vomiting and diarrhea that results in fluid losses, and occasionally pancreatitis or peritonitis that results in redistribution of fluid and consequently leads to a negative fluid balance.⁹ It is imperative that these conditions and their sequelae are treated promptly and appropriately via fluid therapy to optimize a successful outcome.

INTRODUCTION TO FLUID THERAPY

Fluid therapy is the most life-saving therapeutic measure when dealing with hypovolemia or dehydration from gastrointestinal losses. To properly administer fluid therapy to the patient with vomiting or diarrhea, it is imperative to have a basic understanding of the fluid and electrolyte dynamics in this population of sick pets. The appropriate fluid and rate of administration should be based on history, signalment, physical examination and laboratory findings (including electrolytes and acid-base status), and careful assessment of tissue and intravascular (IV) losses.

TOTAL BODY OF WATER AND COMPARTMENTALIZATION

Sixty percent of the adult mammal body weight (BW) is composed of fluid, referred to as the total body water (TBW). This percentage decreases with obesity and age. The TBW is categorized into two main compartments: the intracellular space, which constitutes 67% of this fluid; and the extracellular space, which makes up the remaining 33% (Fig. 1). The extracellular compartment is further divided into the interstitial space, which consists of 75% of the extracellular space; and the IV space, which represents the remaining 25%. The IV space represents 8% of BW in the dog and 6.5% of BW in the cat. Loss of fluid from the IV compartment leads to hypovolemia. Dehydration occurs when there is a loss of water from the intracellular and interstitial compartments.¹⁰

DEHYDRATION

There is no sensitive or specific marker available to assess dehydration. An estimate of dehydration is achieved by means of the physical examination, but factors that influence accurate assessment exist, such as age and body condition. For example, the

Box 2**Common causes of diarrhea in dogs and cats***Alimentary Disorders*

- Food indiscretion
- Hypersensitivity
- Food allergy
- Food poison/toxicity
- Food change
- Excess of food
- Trash consumption

Metabolic/Inflammatory disorders

- Stress
- Sepsis
- Inflammatory bowel disease
- Pancreatitis
- Lymphangiectasia
- Stress colitis
- Hemorrhagic gastroenteritis
- Hepatitis
- Cholangiohepatitis
- Chronic kidney disease
- Hyperthyroidism
- Hypoadrenocorticism
- Exocrine pancreatic insufficiency

Neoplastic Disorders

- Carcinoma
- Lymphoma
- Intestinal stromal tumor

Medications

- Laxatives
- Chemotherapy
- Nonsteroidal anti-inflammatory drugs
- Antibiotics

Infectious

- Virus: parvovirus, coronavirus, distemper, rotavirus, feline leukemia, feline immunodeficiency
- Parasites: giardia, helminths
- Bacteria: *Campylobacter*, *Clostridium*, *Salmonella*, *Escherichia coli*

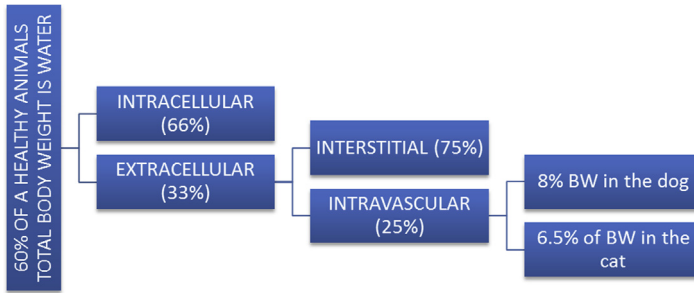


Fig. 1. Total body of water and fluid compartments within the body characterized by percentage of body weight.

older cachexic animal has less skin elasticity and fat compared with the obese pet that has additional lubrication between tissues. Because of these variables, it is best to assess the hydration status via a skin tent over the dorsum of the neck or on the lateral thorax.¹¹ BW seems to be the most objective marker of hydration status. Having a recent past BW is most useful in determining the degree of fluid loss. A loss of 1 mm of water is equivalent to 1 g; therefore, a loss of 1 kg suggests a loss of 1000 mm of body water.¹² Animals with hyporexia and anorexia may lose approximately 0.1 to 0.3 kg BW/day/1000 kcal of energy requirements.¹² An exception occurs in the case of third spacing when there is loss from the circulating volume and no appreciable loss in BW.

In addition to skin turgor and BW, other subjective variables, such as mentation and mucous membranes, provide clues to the degree of dehydration (**Table 1**). Combining

Estimated Degree of Dehydration	Clinical Signs
<5% (subclinical)	Nonapparent on physical examination
5% (mild)	Tachy or dry MM
6%–8% (moderate)	Dry MM Decreased skin elasticity Tachycardia Normal pulse quality Normal arterial blood pressure
8%–10% (severe)	Dry MM Further decrease in skin elasticity Small increase in CRT Weak pulses
~12% (hypovolemia)	Dry MM Increased CRT Skin tent does not return to normal Tachycardia or bradycardia Weak to absent pulses Altered mentation Hypotension Cold extremities Hypothermia

Abbreviations: CRT, capillary refill time; MM, mucous membrane.

the history and laboratory measurements aids the clinician in quantifying the extent of the dehydration most accurately. In cats, a corneal response is used to assess hydration because a delay in the nictating membranes sliding back into its normal anatomic position is a sign of dehydration.

In any disease process, the acute onset of fluid loss originates from the IV space. This results in a shift of water and electrolytes from the interstitial and intracellular compartment as a compensatory response. The tonicity and hydrostatic pressure of the remaining fluid in the extracellular space determines the extent of this shift. As a result, dehydration can occur to different degrees in various compartments and range from being not perceptible until approximately 5% of the BW has been lost as water to a loss of greater than 11% of BW as water being life-threatening.

ELECTROLYTES AND ACID-BASE DISORDERS

The vomiting of gastric or intestinal contents most commonly involves the loss of fluid that contains chloride, potassium, sodium, and bicarbonate. The sequelae of these losses include dehydration along with hyponatremia, hypochloremia, and hypokalemia. Large volumes of fluid are absorbed and secreted by the gastrointestinal tract. To place this in perspective, a 20-kg dog has approximately 2.5 L of fluid entering the duodenal lumen on a daily basis, of this greater than 98% is absorbed.¹² It is approximated that the jejunum absorbs 50% of fluid that passes through its lumen, the ileum 75%, and the colon 90%.¹² This makes it easy to understand why gastrointestinal pathology can quickly lead to dehydration and hypovolemia. In absence of endocrine and renal disease, the magnitude of gastrointestinal losses determines the extent of dehydration and acid-base disturbances.

Emesis results in the loss of gastric secretions that contain potassium. It is calculated that the normal concentration of potassium in gastric secretions ranges between 10 and 20 mEq/L.⁹

High potassium concentrations are found in fecal matter. Profound diarrhea can also result in hypokalemia. Furthermore, severe or chronic hypokalemia aggravates a patient's morbidity by leading to carbohydrate intolerance, anorexia, exacerbation of lethargy, and gastrointestinal hypomotility.

Treatment of acute or severe hypokalemia requires intravenous intervention (Table 2). The rate of potassium chloride administered IV is more important than the quantity and it should at no time exceed a rate of 0.5 mEq/kg/h.¹³ If clinical signs of

Table 2

Recommended amount of potassium chloride and rate of infusion

Serum Potassium Concentration (mEq/L)	Potassium Chloride (mEq) to Add to Fluid (250 mL)	Potassium (mEq) to Add to Fluid (1 L)	Maximal Fluid Infusion Rate (mL/kg/h)
<2.0	20	80	6
2.1–2.5	15	60	8
2.6–3.0	10	40	12
3.1–3.5	7	28	18
3.6–5.0	5	20	25

So as not to exceed 0.5 mEq/kg/h.

Data from Schaer M. Therapeutic approach to electrolyte emergencies. *Vet Clin North Am Small Anim Pract* 2008;38:516.

vomiting are controlled and the patient is eating, chronic mild hypokalemia is addressed via dietary modifications of potassium-rich foods, such as bananas, oranges, or oral potassium supplements (Tumil K, Virbac, Fort Worth, TX).

The most prevalent acid-base disturbance seen in dogs with gastrointestinal disease is metabolic acidosis, which is worsened by poor perfusion. Fortunately, this is typically corrected by use of adequate fluid therapy with a balanced isotonic alkalizing crystalloid, such as lactated Ringer solution or Plasmalyte.¹¹ It is worth mentioning that pyloric foreign bodies and gastrointestinal obstructions that are localized to the proximal duodenum can result in metabolic alkalosis. If this acid-base derangement is noted, 0.9% saline is recommended. Metabolic acidosis or normal acid-base status can also occur with this condition, which underlines the importance of obtaining laboratory diagnostic tests.

CRYSTALLOID FLUID

Isotonic crystalloids are the mainstay treatment of most gastrointestinal disorders. This kind of fluid has an osmolality similar to that of plasma and the extracellular compartment. Sodium has the largest effect on the fluid osmolality because of its having the highest concentration in the extracellular fluid compartment.^{11,14} Water follows sodium. Because of this intimate relationship, the sodium concentration of the fluid is important in selecting the appropriate fluid to treat a condition. The constitution of a fluid, with buffers and electrolytes, is also a consideration in making an adequate fluid choice. In general, vomiting and diarrhea result in isotonic dehydration, and the serum sodium concentration is within the normal reference range. A replacement fluid should be chosen that is nearly physiologic in sodium concentration and osmolality: a sodium concentration of 130 mEq/L to 154 mEq/L (Table 3). If there is a change in the sodium concentration from the normal reference range, then an appropriate fluid should be chosen. If the deficit occurs acutely, the derangement can be corrected acutely, but if it is chronic then it must be corrected slowly over time. If the serum sodium concentration is increased, the patient has hypertonic dehydration and needs more water than salt for replacement. Examples of hypotonic fluids are 5% dextrose and 0.45% saline in 2.5% dextrose. Correction of hypernatremia should not occur any faster than 0.5 mEq/L/h to avoid central pontine myelinolysis.⁹ With hypotonic dehydration, the serum sodium concentration is low and the patient needs more sodium relative to water.

ROUTE OF FLUID THERAPY

The route chosen for fluid administration depends on the severity, nature, and extent of the clinical disorder along with the fluid choice (Table 4). Oral fluid therapy should be reserved for the euhydrated patient that is not vomiting. Electrolyte solutions should be administered at frequent intervals to provide for adequate daily requirements. Promising preliminary data indicate the benefit of oral electrolyte solutions for rehydration in pets with mild to moderate diarrhea. These are safe, effective, and more cost- and time-effective, but further studies are needed.¹⁵ Subcutaneous fluid therapy is used to treat the patient with normovolemia with mild to no evidence of dehydration. A balanced isotonic polyionic crystalloid should be chosen and the amount of fluid administered at each injection site should not exceed 20 mL/kg. The flow of the fluid is determined by the pet's comfort and is generally absorbed within 6 to 8 hours. If fluid pockets persist after this time frame, intravenous fluid (IVF) administration should be implemented to re-establish peripheral perfusion. Avoiding the subcutaneous use of acetated polyionic solutions, such as Normosol-R and Plasmalyte, is

Table 3
Total body of water and fluid compartments within the body characterized by percentage of body weight

Fluid	Osm	Buffer	Na+	Cl-	K+	Ca++	Mg++	CHO-	Indications	Contraindication
Normosol-R	296	Acetate 27 Gluconate 23	140	98	5	0	3	0	Replacement Metabolic acidosis Anorexia Vomiting Hypovolemic shock Diarrhea Renal failure	Hyperkalemia Metabolic alkalosis
PlasmaLyte-A	294	Acetate 27	140	98	5	0	3	0	Replacement Metabolic acidosis Anorexia Vomiting Hypovolemic shock Diarrhea Renal failure	Hyperkalemia Metabolic alkalosis
0.9% Saline	308	0	154	154	0	0	0	0	Replacement Hypovolemic shock Anorexia Vomiting Diarrhea Metabolic alkalosis Hyperkalemia Hypercalcemia Renal failure Acute hyponatremia Chronic hypernatremia	Cardiac disease Liver disease Metabolic acidosis
Lactated Ringer solution	272	Lactate 28	130	109	4	3	0	0	Replacement Hypovolemic shock Vomiting Diarrhea Hypocalcemia Metabolic acidosis Renal failure	Hypercalcemia Hyperkalemia Lymphosarcoma Liver failure

Modified from Mazzaferro E, Powell L. Fluid therapy for the emergent small animal patient. *Vet Clin North Am Small Anim Pract* 2013;43:721–34.

Table 4	
Routes of crystalloid fluid administration	
Route of Administration	Points to Consider
Oral	<ul style="list-style-type: none"> • Reserved for the euhydrated patient • Patients that are not vomiting • Offer ice cubes, small amounts of water, or an oral glucose and electrolyte solution • Give at frequent intervals to provide maintenance daily requirements
Subcutaneous	<ul style="list-style-type: none"> • Use only to treat mild dehydration in absence of other systemic signs • Balance isotonic polyionic sterile fluids (eg, Lactated Ringer solution) • Small dogs and cats without peripheral vasoconstriction • Do not exceed 10–20 mL/kg of fluid per injection site • Flow of fluids is based on patient's comfort • Fluid absorbed within 6–8 h • Do not use hypertonic crystalloids, colloids, or dextrose-supplemented fluid for this route
Intravenous	<ul style="list-style-type: none"> • Moderately to severely dehydrated • Use when accurate deliveries of fluid volume and pharmacotherapeutic agents are required • Benefit: rapid and large administration of fluids, titration of fluids • Allows for potassium supplementation in IVF to replace that lost in vomitus
Intraperitoneal	<ul style="list-style-type: none"> • When intravenous catheter is not successful or possible because this provides rapid access to the circulation • Most commonly needed in emergency situations when immediate intravenous access is not possible for the pediatric or neonatal patient
Intraosseous	<ul style="list-style-type: none"> • Severely anemic pediatric patient • Consider for rewarming patients with hypothermia • Isotonic to mildly hypotonic fluid for rehydration • Intravenous route preferred when possible • Medulla does not collapse during hypovolemia

recommended because these result in patient discomfort. IVF therapy should always be chosen for the dehydrated patient. IVF allows for rapid and accurate administration of volume resuscitation. Hypokalemia is a common finding in the vomiting patient and thus IVF allows for adequate and safe potassium supplementation and delivery. Intraperitoneal and intraosseous routes are not commonly used and reserved for patients in which access to IVF therapy is unsuccessful or not feasible.

FLUID REQUIREMENTS

Emergency Phase

The IV administration rate should be based on parameters of hydration and perfusion with the end goal of achieving normovolemia. If the pet is hypovolemic, then administer one-quarter of the crystalloid shock dose. The shock dosage is derived from the percentage of BW that comprises the IVF compartment. In the dog this is 80 mL/kg, in the cat this is 65 mL/kg. The choice of fluid depends on acid-base status. If the pet is acidotic, use a balanced electrolyte solution; if the pet is alkalotic, use 0.9% saline. If the patient continues to be in shock and the plasma protein concentration is less than 45 g/L, administer a 2.5 mL/kg bolus of hetastarch or pentastarch in a cat and a 5 mL/kg bolus in the dog. This bolus should not be administered any faster than over 15 minutes. This can be repeated in aliquots, but the maximum dose should

not exceed 20 mL/kg in the dog and 10 mL/kg in the cat. If the pet's plasma protein concentration is normal, then continue with small boluses of crystalloid therapy as described previously. The total shock dosage for each individual species should not be exceeded. Most patients are volume resuscitated with less than the maximum dosage. If hypoproteinemia ensues, serum albumin and fresh frozen plasma may be needed depending on the nature and severity of the illness. Fluid resuscitation should continue until there is improvement in perfusion parameters: mentation, heart rate, pulse quality, mucous membrane color, capillary refill time, blood lactate concentration, and urine output. In creating the appropriate fluid plan for a patient, the clinician must consider that approximately 80% of intravenous isotonic crystalloid fluids are absorbed into the interstitial space within an hour.

Rehydration Phase

If the pet is poorly perfused, but not in shock, then fluid volumes are calculated based on the hydration status. The rehydration phase is calculated based on percentage of dehydration (dehydration % \times BW [kg] \times 1000 = mL of fluid deficit), ongoing losses (vomiting and diarrhea), and maintenance requirements. If the pet is febrile, 10% maintenance should be added for each degree Celsius above 39.5°C. The goal is to re-establish 80% to 100% of the fluid deficit within a 24-hour period.

Maintenance Phase

The average figure chosen for TBW in the adult mammal is 60%, hence this is typically used in calculating maintenance fluid therapy. This figure is typically lower in cats and higher in pediatric and neonatal patients. The metabolic fluid requirement is estimated to be an approximation of the metabolic energy requirement. One milliliter of water is required to metabolize 1 kcal of energy. Therefore, metabolic fluid requirements are derived using the formula: $(30 \times \text{kg}) + 70 = \text{mL of water required/day}$ if the pet is greater than 2 kg and less than 100 kg.¹⁶

Monitoring

Frequent examination and reassessment are imperative to meet the unique fluid and protein losses of each individual patient. General guidelines for initial monitoring consist of weighing the patient every 12 hours; monitoring hematocrit and total protein concentration, blood glucose, electrolytes, and blood gases every 6 to 12 hours; and assessing perfusion parameters and fluid in/urine out every 2 to 4 hours. A good rule of thumb to use in evaluating if the fluid requirements have been met or need adjusting is remembering that 1 mL of fluid weighs 1 g. A best practice is to disinfect the scale before and after use. As the patient's clinical status progresses, treatment is tailored to fit ongoing needs, response to the therapeutic regimen, and the course of the disease process.

COMBINATION THERAPY

For control of acute vomiting on a short-term basis or to prevent exacerbation of fluid, electrolyte, and acid-base derangements from further vomiting, antiemetics are incorporated into the treatment regimen. This also helps prevent further complications, such as aspiration pneumonia. Maropitant can be used as an antiemetic IV or subcutaneous and provides adjunct visceral analgesia.¹⁷⁻¹⁹ Gastroprotectants, such as an H₂ antagonist or hydrogen pump inhibitor, are also incorporated for treatment. If there is a concern for esophageal or gastric ulcerations, sucralfate is used. Analgesia may be recommended using narcotic injections. If unobstructive ileus is present, a

promotility agent, such as metoclopramide, is added. Antidiarrheal medications, in general, are not recommended because these decrease peristalsis, which may result in bacterial translocation and severe intestinal overgrowth.²⁰ Antibiotics with broad-spectrum coverage of aerobes and anaerobes should be used if bacterial translocation or a bacterial cause is suspected.

UPDATES IN TREATMENT

The diverse, complex, and dynamic microflora of pathogenic and nonpathogenic bacteria that inhabit the gastrointestinal tract of all mammals is an aspect of gastroenterology that has received much attention and research over the past few years. Much focus has been directed to the mechanisms by which pathogenic bacteria influence intestinal function and induce disease. Most recently, the attention has shifted to focus on the indigenous nonpathogenic microorganisms and the myriad ways in which they benefit the host. The term “probiotic” was first used in 1965 to define “a substance secreted by one microorganism which stimulates the growth of another,” and was thus contrasted with the term antibiotic. The meaning of the word has subsequently evolved to apply to those bacteria that solely contribute to the intestinal balance. The current and more complete definition of a probiotic refers to a preparation or product containing viable, defined microorganisms in sufficient numbers, which alter the microflora and exert beneficial health effects on the host.

Natural or synthetic colloids are used for oncotic support. At present time, the use of a colloids, such as hydroxyethyl starch, continues to remain a viable option for the adjunct treatment of volume resuscitation. This is especially true in the patient with hypovolemia with increased vascular permeability and low colloid osmotic pressure. Colloid therapy increases the volume of IV fluid retention and decreases the overall use of crystalloid therapy. The most current shock dosage recommendation for the use of hydroxyethyl starch is up to 20 mL/kg in the dog and up to 10 mL/kg in the cat. This is an area under current scrutiny because new studies reveal that hydroxyethyl starch may be associated with a negative prognosis.^{21–24} This is caused by the concern for colloids causing fluid overload, hemodilution, and coagulation anomalies (eg, thrombocytopenia, increased fibrin clot fragility, decreased coagulation factors VIII and von Willebrand factor). New evidence-based data indicate concern for renal injury and allergic reactions in emergent fluid therapy in humans, but this has not been extrapolated or perceived in veterinary medicine. There are no current contraindications for the use of colloid therapy in the coagulopathic veterinary patient; however, caution and clinical judgment should be used when in these cases.

REASONS FOR TREATMENT FAILURE

Dehydration gives the clinician a preliminary assessment of the patient’s clinical status, but it must be remembered that this is purely an estimation and can result in a calculation error. The most common reasons for calculation error include inappropriate estimation of the patient’s dehydration status, larger losses than anticipated, diuresis from trying to correct fluid deficit too quickly, and increased sensible losses (eg, polyuria, panting, fever).

Cats can also suffer from an inappropriate fluid plan, because they are less tolerant to aggressive fluid therapy due to occult cardiac disease, a lower metabolic rate, and a smaller blood volume.^{25–29} Overhydration can occur in cats and dogs from such conditions as systemic inflammation, hypoproteinemia, kidney disease, and cardiac disease.²⁵ Therefore, the importance of reevaluating and reassessing the patient cannot be overemphasized. **Box 3** provides a complete list of clinical signs that should be

Box 3**Monitoring response to therapy**

1. Underhydration
 - a. Persistent tachycardia
 - b. Poor pulse quality
 - c. Inadequate urine output
 - d. Weight loss
2. Overhydration
 - a. Chemosis
 - b. Serous nasal discharge
 - c. Weight gain exceeds that expected to accomplish rehydration
 - d. Excessive decrease in PCV/TS
 - e. Excessive urination
 - f. Sudden increase or persistently elevated CVP
 - g. Increased RR and/or RE
 - h. Subcutaneous pitting edema
 - i. Pulmonary crackles (late indicator)

Abbreviations: CVP, central venous pressure; PCV, pack cell volume; RE, respiratory effort; RR, respiratory rate; TS, total solids.

used in assessing underhydration and overhydration. If overhydration is noted, discontinue IVF and administer 2 mg/kg of furosemide IV.

SUMMARY

Adequate fluid therapy strongly relies on the astute clinician being able to detect and correct the underlying cause of fluid and electrolyte losses. Fluid therapy should be tailored to the patient's dynamic condition, and fluid selection and volume may change throughout the progression of therapy. Assessment of fluid loss is only an estimate, and therefore it is most important to let the patients' response to therapy guide the fluid regimen. Developing an appropriate and evolving fluid therapy plan is an important tool to decrease the length of hospitalization and improve care for the patient. Monitoring weight is the most sensitive tool for assessment of dehydration and rehydration because acute changes in weight reflect acute gain or loss of body water. The clinician must remember that a drastic gain or loss of 1 kg is approximately the equivalent of gaining or losing 1 L of fluid. Following hematocrit and total proteins serially during fluid therapy also alerts the clinician to the effectiveness of therapy because a decrease in both suggests successful IV rehydration. Serum electrolytes and acid-base status should also be monitored. Vomiting and diarrhea are common disorders encountered in veterinary medicine, and when treated appropriately most often have a positive outcome.

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