Evaluation of an oral electrolyte solution for treatment of mild to moderate dehydration in dogs with hemorrhagic diarrhea

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Objective—To determine the safety and efficacy of an electrolyte solution for oral administration (OES) for the correction of mild to moderate dehydration associated with hemorrhagic diarrhea in dogs.

Design—Nonrandomized, noncontrolled clinical trial.

Animals—20 dogs that had hemorrhagic diarrhea with < 3 episodes of vomiting.

Procedures—All dogs underwent testing for parvovirus infection, were given maropitant citrate to control emesis, and were offered an OES. Intravenous crystalloid fluid administration was performed when dogs refused the OES or had vomiting, a 5% increase in PCV; 5% decrease in body weight, serum creatinine or BUN concentration higher than at admission, or clinically important alterations in blood electrolyte or serum glucose concentrations.

Results—13 (65%) dogs voluntarily consumed the OES; 7 (35%) dogs refused the OES and received a balanced electrolyte solution IV instead. All 13 dogs in the OES group consumed the solution ≤ 5 hours after hospital admission. Eight and 16 hours after admission, PCV and serum total protein and BUN concentrations were significantly lower than at hospital admission in the OES group, whereas no significant changes were identified in venous blood pH, base excess, and concentrations of sodium, potassium, chloride, ionized calcium, ionized magnesium, and lactate. The cost of treatment was significantly less for the OES group than for the IV treated group.

Conclusions and Clinical Relevance—Rehydration therapy with an OES was effective and safe in dogs with mild to moderate dehydration associated with hemorrhagic diarrhea. Potential benefits of this treatment approach for gastroenteritis in dogs, compared with traditional IV fluid administration, include lower owner-related veterinary costs and decreased staff time associated with treatment. (J Am Vet Med Assoc 2013;243:851–857)
moderate dehydration secondary to gastroenteritis. In a randomized controlled trial in children with gastroenteritis, ORT was found to be as effective as IV fluid administration in moderately dehydrated children. Compared with the IV approach, ORT was initiated more quickly, often in the emergency department waiting room, and was the preferred treatment chosen by parents. In addition, costs of medical treatment, duration of hospitalization, and demands on staff time were significantly lower with ORT.

In veterinary medicine, reports of the use of ORT have involved calves with diarrhea, horses requiring rehydration, and a small number of working dogs during exercise. To the authors’ knowledge, no clinical studies have been conducted to evaluate the use of an OES for the treatment of dehydration induced by diarrhea in dogs. Therefore, the purpose of the study reported here was to determine the safety and efficacy of an OES for the correction of mild to moderate dehydration associated with hemorrhagic diarrhea in dogs.

Materials and Methods

Animals—Dogs were eligible for inclusion in the study when they had been admitted to the emergency service at the Matthew J. Ryan Veterinary Hospital between December 2010 and May 2012 for the treatment of sudden onset of hemorrhagic diarrhea. Owner consent was obtained for all participating dogs. Dogs were excluded when they met any of the following criteria: >3 episodes of vomiting in the 24-hour period prior to hospital admission, hypotension (systolic blood pressure <100 mm Hg) detected at hospital admission, age <1 year, incomplete vaccination history, existing parovirus infection, concurrent medical illness (ie, renal, endocrine, or heart disease), or lack of owner consent for study participation. The study protocol was approved by the Institutional Animal Use and Care Committee of the University of Pennsylvania.

Prior to study commencement, blood samples were collected for initial assessment of PCV; serum total protein concentration (determined with refractometry); venous blood electrolyte concentrations; whole blood glucose, lactate, BUN, and creatinine concentrations; and venous blood pH, bicarbonate concentration, and base excess determined by means of a point-of-care analyzer. An initial indirect Doppler or oscillometric blood pressure measurement was obtained at a brachial or saphenous artery. Initial body weight was recorded, and a parovirus fecal antigen test was performed. In addition, all dogs were given an SC injection of maropitant citrate (1.0 mg/kg [0.45 mg/lb]) to control emesis.

Study protocol—Following the initial assessments, each dog was offered a room-temperature OES designed for use in dogs (Appendix). The OES was offered every 4 hours in a bowl placed nearby or in the dog’s cage. The volume of OES initially provided was calculated on the basis of an estimate of 7% dehydration (0.07 × body weight) to be replaced over 12 hours plus maintenance fluid requirements (2 mL/kg/h) and an estimate of ongoing losses (2 mL/kg/h). The formula used to calculate maintenance fluid requirements was based on data and formulas used in studies of daily water requirements in dogs. When the dog consumed all of the OES, half of the initial volume was additionally offered. The volume of OES consumed was recorded every 4 hours, and additional OES was offered. Water was not offered during the study period. All other treatments and additional diagnostic evaluations were performed at the discretion of the attending veterinarian.

Information regarding the number of vomiting episodes, presence of diarrhea, and changes in appetite that occurred during the 24 hours prior to hospital admission, as well as any previous episodes of gastroenteritis, was recorded at hospital admission. Blood samples were collected and hematologic analyses were performed every 8 hours, beginning at hospital admission. Body weight, blood pressure as measured with a noninvasive method, urine output, and frequency and estimated volume of diarrhea and emesis were recorded at the same time points.

Dogs were administered an isotonic balanced electrolyte solution IV (instead of the OES) at a rate determined by the attending veterinarian when they refused to drink the OES or had persistent vomiting, a 5% increase in PCV, a 5% decrease in body weight, a serum BUN or creatinine concentration higher than the admission value or upper reference limit, or clinically important alterations in circulating concentrations of electrolytes or glucose. For study purposes, these dogs were designated as the IVT group; their data were included in the statistical analysis of initial characteristics and were compared with those of the dogs that voluntarily consumed the OES (ORT group).

Treatments administered and the results of diagnostic testing were recorded. Final treatment costs, excluding those of diagnostic testing, were recorded. Diagnostic testing costs were not included in the calculation of final treatment costs because the tests performed varied widely among dogs. The owners of the dogs in the ORT group were contacted between 24 and 72 hours after hospital discharge to determine whether their dogs’ illness had resolved and to assess for the development of any complications associated with the OES.

The OES was considered to be safe when there was an absence of any electrolyte abnormalities or adverse clinical events such as aspiration of regurgitated stomach contents or hypotension. Effectiveness of the OES was defined as the ability to restore hydration as determined by the attending clinician on the basis of physical examination findings and absence of any withdrawal criteria. In addition, decreases in PCV and serum total protein concentration from the initial admission values, weight gain, urination during hospitalization, and survival to hospital discharge were assessed as indicators of improved hydration.

Statistical analysis—Continuous data such as blood or serum analyte concentrations were evaluated for normality of distribution with the Shapiro-Wilk test. Categorical data such as breed, sex, and signs of lethargy at hospital admission (ie, initial values) were compared between the ORT and IVT groups by means of the Fisher exact test, whereas continuous data were compared between groups with the Student t test or rank sum test. Within the ORT group, initial val-
ues were compared with the 8- and 16-hour values by means of 1-way repeated-measures ANOVA or Friedman repeated-measures ANOVA on ranks. Multiple comparisons were performed following the Holm-Sidak or Tukey method, as appropriate. A value of \( P < 0.05 \) was considered significant for singular comparisons. Although the value of correcting for multiple tests is highly debated,\(^{17}\) for statistical evaluations with multiple comparisons, the \( P \) value that was considered significant was calculated by application of a Bonferroni correction.\(^{4}\) For comparison of hematologic variables measured at hospital admission and 8 and 16 hours later, Bonferroni-corrected results were considered significant for values of \( P < 0.004 \). All other analyses were performed by use of a statistical software package.\(^{6}\)

### Results

#### Animals

Twenty dogs were enrolled in the study, including 9 mixed breeds, 2 German Shepherd Dogs, 2 Greyhounds, and 1 dog of each of the following breeds: Dachshund, Miniature Poodle, Papillon, Labrador Retriever, Boxer, Yorkshire Terrier, and Rhodesian Ridgeback. There were 3 males, 8 castrated males, 1 female, and 8 spayed females. The mean age of the dogs was 4.0 years (range, 1.5 to 12 years), and median body weight was 20.25 kg (44.55 lb; range, 2.16 to 45.60 kg [4.75 to 100.32 lb]).

The duration of clinical signs of gastroenteritis ranged from 1 to 4 days, with a median duration of 2 days. All 20 dogs had been brought to the emergency service for hematochezia, and 17 (85%) had concurrent vomiting. The median number of episodes of vomiting prior to hospital admission was 1 (range, 0 to 3). Eleven (55%) dogs had a previous episode of gastroenteritis that had resolved with medical treatment. All dogs had negative results of parvovirus fecal antigen testing. Fifteen (75%) dogs had a microscopic evaluation of feces performed. Campylobacter-like organisms (curved rods) were identified in fecal samples of 3 dogs, and clostridial endospores were identified in samples from 2 others. Findings for the other 10 dogs were unremarkable. One dog had fecal parasite screening performed, and whipworms were identified.

Nineteen of 20 (95%) dogs received antimicrobials for treatment of diarrhea. Most (16/20 [80%]) were given metronidazole (10 mg/kg [4.5 mg/lb], IV or PO, q 12 h) for treatment of hematochezia. Two of the 3 dogs with campylobacter-like organisms identified in fecal samples were treated with tylosin\(^{10}\) (50 to 80 mg/kg/d [22.7 to 36.4 mg/lb/d], PO), and 1 dog received enrofloxacin (10 mg/kg, q 24 h). One dog did not receive any antimicrobials. Other medications administered included famotidine (n = 1), ondansetron (1), buparenonephine (1), fenbendazole (1), and a combination of praziquantel, pyrantel pamoate, and febantel (1).

The median duration of hospitalization for all 20 dogs was 21 hours (range, 7 to 72 hours). Two (10%) dogs were hospitalized for 7 and 8 hours, respectively; and 11 (55%) were hospitalized for 12 to 24 hours. Five (25%) dogs were hospitalized for 24 to 36 hours, and 2 (10%) dogs were hospitalized for 72 hours. All dogs survived and were discharged from the hospital.

### Treatment Groups

Thirteen of 20 (65%) dogs voluntarily consumed the OES and were assigned to the ORT group, whereas 7 (35%) dogs refused to drink the OES and received an electrolyte solution IV instead (IVT group). The IVT group included 5 dogs that did not consume any of the OES (0 mL/kg), 1 that drank 6.2 mL of OES/kg (2.8 mL/lb), and another that drank 1.0 mL of OES/kg. The median interval between hospital admission and IV administration of fluids for these 7 dogs was 5.5 hours (range, 2 to 8 hours). Two of these dogs had hematologic tests repeated at 8 hours after admission and prior to initiation of IV fluid administration, and each had a PCV that had increased from the initial (admission) value by 4%. One dog was also included in the IVT group because of an additional vomiting episode, which occurred within 2 hours after hospital admission and prior to maropitantcitrate administration.

All 13 dogs in the ORT group voluntarily consumed the OES within 3 hours after hospital admission, for a median volume of 4.5 mL/kg (2.0 mL/lb; range, 0.3 to 7.6 mL/kg/h [0.14 to 3.5 mL/lb/h]). The ORT dogs’ consumption volume (median, 1.082 mL/kg) was significantly \( (P < 0.001) \) greater than that of the dogs in the IVT group (median, 0 mL/kg).

Comparison of characteristics and treatment costs between ORT and IVT groups—A significant difference was detected in the median number of vomiting episodes prior to hospital admission for dogs in the IVT group (median, 2; range, 0 to 3) versus the ORT group (median, 1; range, 1 to 3; \( P = 0.028 \)). The only difference in initial blood values between groups was in potassium concentration, which was significantly \( (P = 0.03) \) lower in the IVT group (3.8 ± 0.33 mEq/L) than in the ORT group (4.1 ± 0.24 mEq/L, Table 1). Initial mean systolic blood pressure was not significantly \( (P = 0.31) \) different between the ORT (138 ± 42 mm Hg) and IVT (134 ± 23 mm Hg) groups. Systolic blood pressure remained within reference limits in all dogs throughout the duration of hospitalization.

Median duration of hospitalization was not significantly \( (P = 0.45) \) different for the ORT group (20 hours; range, 7 to 72 hours) versus the IVT group (21 hours; range, 14 to 72 hours). One dog in the ORT group and 1 dog in the IVT group each had an additional episode of vomiting, and 3 dogs in each group had additional episodes of diarrhea during hospitalization \( (P > 0.60) \). Cost of treatment was significantly \( (P = 0.006) \) less for dogs in the ORT group (median, $433; range, $414 to $435) than for dogs in the IVT group (median, $389; range, $424 to $979).

Effect of ORT—To evaluate effectiveness of the OES, initial hematologic values of dogs in the ORT group were compared with their values at 8 and 16 hours after hospital admission (Table 2). To evaluate the safety of the OES, hematologic values were assessed for significant changes every 8 hours during hospitalization. The PCV and serum total protein and BUN concentrations were significantly lower than initial values at the 8- and 16-hour time points. At hospital
admission, the PCV was higher than the upper reference limit in 8 of the 13 dogs and within reference limits (35% to 55%) in the remaining 5 dogs. At 8 hours after admission, the PCV was lower than initial values in 9 dogs (range of decrease, 3% to 13%), unchanged in 2 dogs, increased (from 43% to 47%) in 1 dog, and not measured because of a laboratory error in 1 dog. Of the 9 dogs with a high PCV at admission, 7 had a PCV within reference limits at 8 hours, whereas values for 2 dogs remained high (57% and 59%). At 16 hours after admission, all dogs had a PCV within reference limits; however, the dog with the PCV of 57% at 8 hours had been discharged from the hospital and did not have its PCV measured at the 16-hour time point.

No significant differences from initial values were identified 8 or 16 hours after admission for venous blood pH, base deficit, or concentrations of sodium, potassium, chloride, ionized calcium, and ionized magnesium. No difference among time points was detected in serum bicarbonate concentration. The mean blood concentration of ionized magnesium was higher than the upper reference limit (0.41 mmol/L) at all time points. One dog developed a mild increase in blood sodium concentration (151.9 mEq/L) at 16 hours, compared with its initial value (148.5 mEq/L).

Body weight was recorded 8 hours after admission for 10 dogs and at 16 hours for 6 dogs. Mean initial body weight (19.9 kg [43.8 lb]; range, 2.16 to 45.60 kg [4.75 to 100.32 lb]) was not significantly different from the mean value at 8 hours (20.30 kg [44.66 lb]; range, 2.21 to 46.30 kg [4.86 to 101.86 lb]). At that time point, 8 of the 10 dogs had gained weight (median gain, 0.32 kg [0.70 lb]; range, 0.05 to 1.10 kg [0.11 to 2.42 lb]), 1 dog had no weight change, and 1 dog had lost 0.20 kg (0.44 lb). At 16 hours, all 6 dogs evaluated had evidence of weight gain (mean gain, 0.61 kg [1.34 lb]; range, 0.03 to 1.35 kg [0.07 to 2.97 lb]), representing a significant (P = 0.026) increase from initial values. All dogs in the ORT group urinated prior to hospital discharge, with a median interval from admission to urination of 7 hours (range, 2 to 22 hours).

When contacted 24 to 72 hours after their dogs had been discharged from the hospital, all owners of dogs in the ORT group reported resolution of clinical signs. Two owners reported that their dogs developed polyuria following hospital discharge. One of these dogs had consumed 56.8 mL of OES/kg (25.8 mL/lb) over 20 hours (2.8 mL/kg/h [1.3 mL/lb/h]) while hospitalized, and the other dog had

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reference interval</th>
<th>ORT group</th>
<th>IVT group</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCV (%)</td>
<td>35 to 55</td>
<td>56 ± 7</td>
<td>55 ± 4</td>
<td>0.78</td>
</tr>
<tr>
<td>Total protein (g/dL)</td>
<td>6.4 to 8.6</td>
<td>6.6 (5.8 to 7.4)</td>
<td>6.2 (5.0 to 7.6)</td>
<td>0.50</td>
</tr>
<tr>
<td>pH</td>
<td>7.35 to 7.45</td>
<td>7.42 (7.37 to 7.54)</td>
<td>7.40 (7.36 to 7.46)</td>
<td>0.38</td>
</tr>
<tr>
<td>Sodium (mmol/L)</td>
<td>140 to 150</td>
<td>145 (143 to 154)</td>
<td>145 (135 to 148)</td>
<td>0.64</td>
</tr>
<tr>
<td>Chloride (mmol/L)</td>
<td>109 to 120</td>
<td>113 ± 3</td>
<td>112 ± 3</td>
<td>0.50</td>
</tr>
<tr>
<td>Potassium (mmol/L)</td>
<td>3.9 to 4.9</td>
<td>4.1 ± 0.24</td>
<td>3.8 ± 0.33</td>
<td>0.03</td>
</tr>
<tr>
<td>Ionized calcium (mmol/L)</td>
<td>1.2 to 1.4</td>
<td>1.1 ± 0.1</td>
<td>1.1 ± 0.1</td>
<td>0.85</td>
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<tr>
<td>Ionized magnesium (mmol/L)</td>
<td>0.25 to 0.41</td>
<td>0.42 ± 0.04</td>
<td>0.41 ± 0.03</td>
<td>0.28</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>85 to 112</td>
<td>108 ± 17</td>
<td>128 ± 23</td>
<td>0.05</td>
</tr>
<tr>
<td>Lactate (mmol/L)</td>
<td>0.5 to 2.5</td>
<td>1.3 (0.5 to 5.3)</td>
<td>1.4 (0.9 to 2.3)</td>
<td>0.76</td>
</tr>
<tr>
<td>BUN (mg/dL)</td>
<td>5 to 30</td>
<td>17 ± 5</td>
<td>21 ± 9</td>
<td>0.3</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>0.7 to 1.8</td>
<td>0.9 (0.6 to 1.5)</td>
<td>0.8 (0.7 to 0.9)</td>
<td>0.36</td>
</tr>
<tr>
<td>Base excess (mmol/L)</td>
<td>−4.0 to 4.0</td>
<td>−2.3 ± 2.5</td>
<td>−5.3 ± 3.7</td>
<td>0.05</td>
</tr>
<tr>
<td>Bicarbonate (mmol/L)</td>
<td>17 to 28</td>
<td>21.1 ± 3.0</td>
<td>19.1 ± 4.0</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Values of P < 0.05 were considered significant.

Bonferroni-corrected values of P < 0.004 were considered significant.

Values with the same superscript letters within the same row are significantly different.
consumed 133.2 mL of OES/kg (60.5 mL/lb) over 24 hours (5.6 mL/kg/h [2.5 mL/lb/h]).

Discussion

Enteritis resulting in sudden onset of hematochezia in dogs can have several causes, including but not limited to infection with enteropathogens, dietary hypersensitivity, ischemia within the gastrointestinal tract, and systemic disease. In diarrheal diseases, a rearrangement in the secretory-absorptive processes of the gastrointestinal tract develops through osmotic or secretory mechanisms, resulting in water and electrolyte losses. Damage to the epithelial intestinal barrier, such as that caused by many enteropathogens, may lead to a decrease in absorptive capabilities.\(^2\)\(^-\)\(^4\) When the absorptive capacity of the intestines is overwhelmed, osmotically active particles retain water in the intestinal lumen, resulting in excessive fecal water loss.\(^2\)\(^-\)\(^4\) Such water loss can result in dehydration and potentially hypovolemia when oral intake of water is not adequate or the patient is vomiting. Electrolyte abnormalities resulting from diarrhea are not common but can develop with diarrhea of osmotic origin or when concurrent vomiting exists.

The absorption of water and nutrients within the small intestine is typically dependent on the osmotic gradient dictated by sodium transport through 3 mechanisms: neutral sodium and chloride transport, sodium absorption coupled to the absorption of organic solutes such as glucose and amino acids, and electrogenic sodium absorption.\(^18\) The rationale for using an OES to rehydrate animals with diarrheal diseases is that disruption of these processes occurs except for the process of sodium transport coupled to glucose and other organic solutes. Therefore, OESs for ORT are designed to take advantage of this sodium-coupled water absorption in the small intestine, maximizing water uptake and thereby improving hydration status.\(^19\)

The World Health Organization has used OESs for over 30 years, successfully reducing the number of deaths due to diarrheal diseases worldwide.\(^7\) Compared with IV fluid administration, ORT promotes physiologic water and electrolyte absorption in the gastrointestinal tract, allowing for a painless, safer, and less expensive treatment option for mild to moderate dehydration.\(^8\)\(^-\)\(^10\) Given these advantages, it is not surprising that OESs have been evaluated and used extensively in veterinary medicine for the treatment of diarrhea in calves.\(^10\)\(^-\)\(^11\) Although several types of OESs are available to small animal practitioners, to the authors’ knowledge, the safety and usefulness of these OESs have not previously been investigated for the treatment of dehydration associated with diarrhea in dogs.

The results of the present clinical study suggested that ORT with an OES can be safely used for the treatment of dehydration associated with hemorrhagic diarrhea in dogs, and treatment costs associated with ORT were significantly lower than those associated with IVT. The OES was readily consumed by 65% (13/20) of the dogs, with many dogs consuming large volumes (as much as 174 mL/kg [79.1 mL/lb]). No clinically important changes in blood pH, glucose, or electrolyte concentrations were evident 8 or 16 hours after hospital admission and initiation of ORT, supporting its safety for use in healthy dogs. However, the OES used should be administered cautiously or avoided in dogs with systemic disease, particularly those with heart or kidney disease or hypertension, because of the solution’s sodium content.

The mean blood concentration of ionized magnesium was slightly higher than the upper reference limit at all time points in dogs that underwent ORT. Because the kidneys are the main regulators of total body magnesium content, the increase we detected might have reflected a decrease in renal perfusion leading to retention of magnesium.\(^20\) However, no dogs had evidence of hypotension or clinical signs consistent with hypoperfusion. In addition, there were other indications of improved hydration status during treatment, including urine production and weight gain; therefore, we are unsure about the clinical relevance of this finding. Interestingly, dogs in which IVT had to be used for rehydration because of inadequate consumption of the OES had a significantly lower initial blood potassium concentration and higher number of vomiting episodes prior to hospital admission. Hypokalemia can be a complication of vomiting and diarrhea because of the decrease in oral intake and gastrointestinal tract loss of potassium.\(^3\) Although within reference limits, the lower blood potassium concentration combined with the higher number of vomiting episodes in the IVT group suggested that these dogs may have been more severely affected by their gastrointestinal tract disease, which might also explain their failure to voluntarily consume the OES.

The effectiveness of the ORT was evaluated subjectively by the attending veterinarian in addition to objective measurements of hydration. All dogs in the ORT group were adequately hydrated and had produced urine by the time of hospital discharge. Furthermore, most dogs in this group gained weight during hospitalization, and weight gain was significant in those dogs for which body weights were measured 16 hours after admission. Additionally, mean PCV and serum total protein concentration decreased significantly at 8 and 16 hours, compared with initial admission values. These indicators of hydration status must be used in conjunction with physical examination because other factors, such as anemia or hypoalbuminemia, may affect both variables. The decrease in serum total protein concentration in the ORT group may have been attributable to ongoing intestinal protein loss resulting from the diarrhea rather than an improvement in hydration status. Additionally, the decrease in PCV could have been attributable to measurement error or gastrointestinal hemorrhage, given that the affected dogs had gross evidence of blood in their feces. However, it is unlikely that ongoing blood loss into the gastrointestinal tract was an important contributing factor because only 3 of the 13 dogs that underwent ORT had additional small episodes of diarrhea.

When the underlying etiology of the diarrhea is unknown, the treatment approach is primarily supportive, and hospital admission is usually recommended for dogs with clinical evidence of dehydration. Anti-
microbials are routinely administered to address a possible bacterial infection and were administered to 95% (19/20) of the study dogs. Interestingly, only 6 (30%) dogs had additional episodes of diarrhea after hospital admission, and all dogs had complete resolution of diarrhea at hospital discharge. Because the study was not designed to evaluate other treatment effects, it is unknown whether the clinical improvement observed was a result of antimicrobial or other drug administration or whether the diarrhea would have improved without treatment. Additional prospective clinical studies are needed to determine the effect of antimicrobials and other treatments in the resolution of hematochezia associated with sudden onset of gastroenteritis in dogs.

Dogs were hospitalized for a short period in the study, with 75% of dogs discharged from the hospital ≤ 36 hours after admission. However, when speed of rehydration is an important clinical concern or the dog has concurrent hypotension, IVT is the superior choice. Although some experimental evidence exists that an OES may be useful in the correction of hypovolemia associated with diarrhea in calves and burn injury in dogs, at this time, the authors do not recommend treating hypovolemia with an OES. In the aforementioned patients, the solutions were administered directly into the stomach, which would require heavy sedation, endotracheal intubation, and orogastric tube placement in a dog. There is also a risk of aspiration of stomach contents following administration of the OES, and IVT remains the gold standard in veterinary critical care for the treatment of hypovolemia.

In addition to or in the place of oral administration of electrolyte solutions, SC administration may also be considered as a method for rehydration. However, SC administration alone may not always provide adequate fluid volumes in all circumstances; it may take hours before the fluid is completely absorbed from the subcutaneous space, and this treatment approach should not be used without additional intervention in animals that are hypovolemic. To the authors’ knowledge, no clinical studies have been conducted to evaluate the effectiveness of SC fluid administration for rehydration; however, anecdotaly, it is considered to be clinically effective in some animals.

The present study had several limitations. First, attending veterinarians subjectively determined the hydration status of dogs and recommended hospital admission. Ideally, objective measurement of hydration by use of a hydration scale, as is performed for children and calves, would have been made to determine the need for rehydration treatment and evaluate that treatment’s effectiveness. Because the study was not designed to compare ORT with IVT for correction of dehydration, the lack of a more objective measurement of hydration should not have adversely affected the results. Second, some of the dogs included in the study may have improved without medical treatment. However, the lack of adverse effects from ingestion of large quantities of the OES in the otherwise healthy dogs supports the use of the OES evaluated in our clinical study for ORT. Finally, dogs were not offered water. Because many dogs in the ORT group consumed large quantities of OES, we believe the OES may be more palatable than water. Randomized, controlled clinical trials are needed to compare the effects of water versus an OES for use in ORT and to compare ORT with IVT in larger numbers of dogs. However, the study findings suggested that ORT therapy with the OES evaluated is a safe and effective treatment option in dehydrated, otherwise healthy dogs with sudden onset of hemorrhagic diarrhea. In this study, ORT was significantly less expensive than IVT and, when successful, may be less demanding for veterinary staff and could potentially be initiated or maintained by the dog owner.

References

Appendix

Composition of an electrolyte solution designed for oral administration and evaluated for treatment of mild to moderate dehydration in dogs with hemorrhagic diarrhea.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mmol/L)</td>
<td>152</td>
</tr>
<tr>
<td>Potassium (mmol/L)</td>
<td>7.1</td>
</tr>
<tr>
<td>Chloride (mmol/L)</td>
<td>109</td>
</tr>
<tr>
<td>Bicarbonate (mmol/L)</td>
<td>25</td>
</tr>
<tr>
<td>Magnesium (mmol/L)</td>
<td>2.3</td>
</tr>
<tr>
<td>Glucose (mmol/L)</td>
<td>13.7</td>
</tr>
<tr>
<td>Osmolality* (mOsm/L)</td>
<td>332</td>
</tr>
<tr>
<td>Effective strong ion difference (mEq/L)†</td>
<td>50</td>
</tr>
</tbody>
</table>

*Osmolality was calculated as 2([Na+] + [K+]) + ([glucose]/18), where brackets represent concentration. †Effective strong ion difference = [Na+] + [K+] – [Cl–].