Fluid Therapy for Colic and Diarrhea: Tricks That Can Be Used In the Field

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Fluid and electrolyte therapy is integral to successful management of colic patients and includes IV fluid administration, enteral fluids administered via a nasogastric tube, and oral administration of hypertonic electrolyte slurries. Over the past few years, economic pressures have led to increased reliance on enteral fluid therapy for treatment of large colon impactions and displacements, and even colitis cases. Both experience and recent reports reveal a high success rate for this approach.

BODY FLUID AND ELECTROLYTE BALANCE

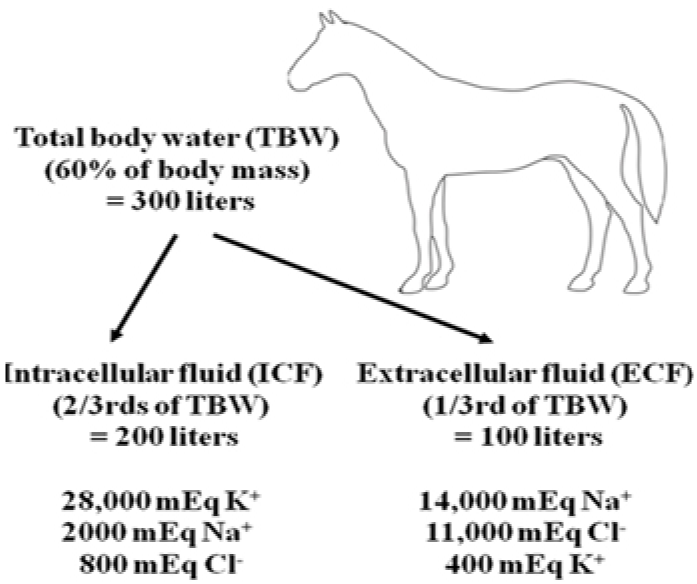
Before specific aspects of fluid therapy are discussed, it is important to review normal water and electrolyte balance in the healthy horse. Under mild ambient conditions, horses have a water requirement of about 50 mL/kg/day or about 25 liters (or 6 gallons) per day for a typical 500 kg horse that is eating normally. In horses fed a typical hay and grain diet, most of this water (> 90%) is taken in by periprandial drinking with the remainder coming from feed. This water is subsequently eliminated through feces, urine, and insensible routes (via sweating and humidification of inspired air). When a horse is off feed, water requirement and intake may drop by more than 50% without development of significant dehydration due to a similar decrease in water output in feces and urine. Next, daily water requirement is increased in exercising horses (to replace sweat losses), horses with chronic diarrhea, and in horses stabled under conditions of high heat and humidity. A comment about water intake by foals is also warranted: foals less than 30 days of age are rarely observed to drink water because they often ingest a volume of milk in excess of 20% of their body mass daily. This equates to a fluid intake approaching 250 mL/kg/day or five times that of the adult horse. To eliminate this considerable water intake, healthy foals urinate almost every time they get up to nurse and their urine is so dilute (specific gravity around 1.005) that it looks like water. Horses are also different than small animals when it comes to body fluid stores: healthy horses have a substantial reserve of water and electrolytes in the lumen of the intestinal tract (10–12% of total body mass is gut contents) that can initially be used to replace some types of fluid loss (e.g., sweating during prolonged exercise or transport). However, this reserve becomes useless with other problems (e.g., profuse diarrhea) and has likely already been depleted in horses that have been off feed for 2–4 days.

Body fluid is distributed in several compartments as illustrated in Figure 1. Water is the most abundant molecule in the body (total body water [TBW] accounts for 60–65% of body mass). Because the body is made up of cells, it should not be surprising that most water (two-thirds of TBW) is found inside cells, collectively called the intracellular fluid space (ICF). The remaining one-third of TBW is outside cells, in the extracellular fluid space (ECF), which can be further subdivided into the plasma space (25–30 liters), the interstitial spaces between cells (40–45 liters), and the transcellular space (about 30 liters, primarily in the lumen of the gastrointestinal tract but to a lesser extent in cerebrospinal fluid, pleural fluid, peritoneal fluid, and within joints). In addition to water, body fluids are rich in electrolytes but the electrolyte composition varies greatly between ICF and ECF (Figure 1).

As with water balance, diet can also affect electrolyte balance. Most hays are rich in potassium (K^+) but low in sodium (Na^+). Thus, horses typically consume diets that are excessive in K^+ and marginal in Na^+. This is reflected by the fact that urine of normal, hydrated horses usually contains high concentrations of K^+ (200–400 mEq/L) and low concentrations of Na^+ (0–50 mEq/L). Further, with disorders causing decreased feed intake and dehydration, the ability of the kidneys to conserve (reabsorb) Na^+ is much greater than that for K^+. This point is particularly important to remember for two reasons: 1) most crystalloid fluids that are administered intravenously are similar in electrolyte composition to plasma - that is, they are high in Na^+ but contain little K^+; and 2) horses that are off feed will have continued, obligate losses of K^+ in urine. Without adequate supplementation of K^+, horses that are receiving intravenous fluids for more than a couple of days are at risk of further depletion of K^+ from body stores and this could contribute to muscle weakness (e.g., another complicating factor for post-operative ileus).

Another electrolyte that can be significantly affected by diet is calcium (Ca^{++}). Horses are somewhat unique among the large domestic species in that Ca^{++} metabolism is not well regulated at the gut. As a consequence, horses absorb excessive amounts of Ca^{++} from feed and this excess is eliminated in the form of calcium carbonate crystals in urine (a major cause for the turbid appearance of normal equine urine). Thus, anorexia in horses is almost always accompanied by a modest decrease in total serum Ca^{++} concentration (e.g., from a normal value of 12 mg/dL to 10 mg/dL [3 mmol/L to 2.5 mmol/L]) and decreased turbidity of urine. Fortunately, this trend toward mild hypocalcemia rarely complicates the primary disease process although it can exacerbate muscle weakness and decrease cardiac contractility.

Figure 1. Body fluid compartments and exchangeable electrolyte contents of a 500 kg horse.



Determining When and What Type of Fluid Therapy is Needed

Assessment of Hydration Status

To determine whether or not a sick horse needs fluid therapy, hydration status must first be assessed and an estimate of dehydration made. Unfortunately, clinical examination findings do not become abnormal until a horse becomes 3–5% dehydrated, with the percent value referring to percentage decrement in body mass due to fluid loss. For example, an estimate of 3–5% dehydration would lead to an estimated 15–25 liter fluid deficit in a 500 kg horse. Abnormal clinical findings supporting dehydration may include tacky oral membranes; a cool nose, ears, and extremities; poor distensibility of jugular veins (noticed when collecting blood samples or inserting a catheter); and delayed recovery of tented skin. In the author’s experience, noting the temperature of the nose, ears, and extremities is one of the more useful indicators of hydration status, especially in neonates (e.g., whether the limbs are cool from the fetlocks down or from the carpi and tarsi down). The most severely dehydrated horses rarely have a fluid deficit greater than 15% (75 liter fluid deficit in a 500 kg horse) and dehydration is estimated between 5–15% on the basis of severity of changes in clinical parameters of hydration status. In addition to examination findings, these also include packed cell volume (PCV) and plasma total solids (TS, measured with a refractometer). However, they must always be interpreted in combination with examination findings because markedly dehydrated horses may have laboratory data altered by disease (e.g., despite severe dehydration, TS may actually be decreased in horses with profuse diarrhea as a result of protein loss in feces). As a rule of thumb, all horses that show clinical evidence of dehydration are candidates to receive fluid therapy.

Route of Administration

With development of 5 liter intravenous fluid bags and systems designed to hang multiple bags (e.g., 20 liters at a time), use of intravenous fluids in equine practice has expanded considerably over the past 10–20 years. Accompanying this advance in treatment capability, a consequence appears to have been a decrease in the use of enteral fluid therapy (i.e., fluids administered by a nasogastric tube). This is somewhat unfortunate because enteral fluids are rapidly absorbed across the stomach wall and in the upper small intestine, as long as that portion of bowel remains functional. In fact, a larger volume of fluids can often be given via this route (e.g., 8 liters every 30–60 minutes via an indwelling nasogastric tube) than can be administered through a single intravenous catheter. Recent work supports that the enteral route may have an additional benefit - specifically, stimulation of intestinal motility. This would be an advantage in a horse with impaction colic, but it may occasionally be accompanied by exacerbation of colic signs during the 10–15 minute period after fluid administration. The only real contraindications for use of enteral fluids are presence of gastric reflux when a stomach tube is passed or severe resistance by the horse when the tube is being passed. Further, enteral fluid solutions can easily be made when needed (e.g., 30 g of salt, either iodized or non-iodized, or lite salt [a 1:1 mix of NaCl and KCl] added to each gallon of water provides an isotonic solution) and are inexpensive. For further convenience, pre-measured amounts of salt or lite salt can be prepared by pharmacy staff or a permanent marker can be used to draw a line on a plastic container (e.g., a 60 mL syringe case or a urine specimen cup) that can be used for stall-side measurement of the appropriate amount of electrolytes to administer.

With more severe dehydration (7–15%), enteral fluids must be administered with caution because absorption may be compromised due to decreased blood flow to the intestinal tract. Thus, more severely dehydrated horses are usually initially treated with intravenous fluids although administration of enteral fluids and electrolytes in the form of oral pastes are often useful components of the fluid therapy plan that can decrease the volume of intravenous fluids used. With a standard intravenous catheter (14 gauge, 13 cm in length) placed in the jugular vein, intravenous fluids can be administered at a rate of 5–7 liters/hour, depending on the height at which fluid bags are hung. Rarely is more than one intravenous catheter required for initial rehydration unless multiple types of products (e.g., crystalloid solutions and whole blood or plasma) are being administered simultaneously.

Type of Fluid

Although water is the most abundant component of most fluid therapy solutions administered intravenously or via a nasogastric tube, these solutions also contain electrolytes and/or nutrients (glucose). The most important electrolytes to consider are Na^+, K^+, chloride (Cl^-), and Ca^{++}. As illustrated in Figure 1, Na^+, K^+, and Cl^- are quantitatively of greatest importance. The latter ion, Cl^-, is the major exchangeable anion and typically follows losses of the major cations, Na^+ and K^+.

As mentioned above, essentially all commercially available crystalloid fluids have an electrolyte composition similar to plasma. Thus, they are rehydration fluids designed to replace acute losses of fluid from the ECF. As a result, most of these solutions are appropriate choices for initial treatment of dehydrated horses and variation in products used between hospitals often reflects different costs and availabilities, rather than a physiological preferable solution. Two further comments about initial rehydration of neonatal foals are warranted. First, most sick foals are not nursing well and have limited energy reserves. Thus, addition of glucose (5–10% dextrose solution) is recommended for initial rehydration of foals less than 30 days of age. A 5% dextrose solution can be made by adding 100 mL of 50% dextrose per liter of crystalloid fluid. Second, foals with uroperitoneum from a ruptured bladder or ureter may have significant hyperkalemia and K^+ free solutions (e.g., 0.9% NaCl, also with 5% dextrose added) are most appropriate for treatment of affected foals.

DEVELOPING A FLUID THERAPY PLAN

Initial Rehydration Plan

Once hydration status has been assessed, a fluid therapy plan can be developed. Initially, plans are made for 12–24 hours and subsequently modified after assessing the patient's response to treatment. The volume of fluid administered should include: 1) amount estimated to correct dehydration; 2) amount needed for maintenance; and 3) amount to replace estimated ongoing fluid losses. As well as being rather variable, the latter is also the most difficult to predict and is of greatest importance in horses with significant ongoing losses in gastric reflux or diarrhea. As an example, assume you are presented with a 500 kg horse afflicted with colitis. The horse has had diarrhea for 2 days, is off feed, and clinical examination findings result in an estimate of moderate (7%) dehydration. A plan for the initial **12 hours** would be formulated as follows:

1. Rehydration needs: 0.07 (estimated 7% dehydration) x 500 kg = 35 kg ≈ 35 liters
2. Maintenance needs: 50 mL/kg/24 h x 500 kg = (25,000 mL/24 hours)/2 = 12.5 liters
3. Ongoing losses: estimated at 2 liters/h x 12 h = 24 liters
4. TOTAL: 35 + 12.5 + 24 = 71.5 liters

Thus, ~ 70 liters of fluid needs to be administered over the initial 12 hours of treatment. This could be accomplished by hanging 14–5 liter bags with an infusion rate of ~ 6 liters per hour. As an alternative, a nasogastric tube could be placed and 10 liters of fluid could be administered 7 times over the initial 12 hours. A combination of intravenous fluids and enteral fluids is probably the most logical approach in this case. Most commonly, however, such horses are treated almost exclusively with intravenous fluids because most clinicians do not want to repeatedly pass a nasogastric tube in a sick, depressed horse and prefer not to place an indwelling nasogastric tube in horses that they are encouraging to eat. From a physiological basis (not to mention a cost basis), however, enteral fluid therapy alone would be a completely acceptable alternative and this point should be remembered when treating horses for which owners may not be able to afford intravenous fluid therapy (especially when the alternative may be euthanasia).

Additives to the Base Fluid

At present, limitations of fluid therapy in equine patients are that commercially available intravenous rehydration solutions fail to address K^+ and Ca^{++} deficits and maintenance fluid solutions (for use once rehydration has been accomplished) are not available. Ideal maintenance solutions would contain less Na^+ and more K^+ and Ca^{++} than rehydration solutions and would also partially supply energy needs. Another factor to consider is the nature of the dehydration being treated. For example, a horse that has become dehydrated over a period of 2 to 4 days (e.g., water deprivation) has a different type of fluid loss than a horse that has developed acute diarrhea over the past 12 hours or has been raced under hot humid conditions after receiving furosemide for prophylaxis against EIPH. In the horse deprived of water, fluid deficits have developed more slowly and dehydration involves a loss of both ECF (Na^+ rich fluid) and ICF (K^+ rich fluid). In contrast, sweating and furosemide administration produce more acute losses of fluid that are predominantly from ECF. Thus, the water deprived horse would have a greater depletion of body K^+ stores while the racehorse would have greater depletion of body Na^+ stores.

It is important to emphasize that most horses have adequate body reserves of these electrolytes and energy to get them through a couple of days of disease. Therefore additives to crystalloid fluids are not routinely necessary for horses receiving fluid therapy for 12–48 hours for supportive treatment for impaction colic or a mild case of diarrhea. This is especially true for patients that, although lethargic, continue to eat 25–50% of their daily feed ration. Additives to the intravenous fluids are most critical for completely anorectic patients receiving intravenous fluids for more than 48 hours and in patients that are losing large amounts of fluid in the form of ongoing gastric reflux or profuse diarrhea.

A common practice to address the anticipated Ca^{++} deficit in anorectic horses is to add 125 ml of a 23% calcium borogluconate solution to each 5 liter intravenous fluid bag. This addition of calcium borogluconate provides about 2.7 g of Ca^{++} in each 5 liter bag that would replace about one-eighth of the exchangeable Ca^{++} pool in a 500 kg horse.

Most crystalloid rehydration fluids contain relatively modest amount of K^+ (5 mEq/L or less for most polyionic solutions); thus, addition of supplemental K^+ to the base fluid may be needed in some instances. Because K^+ is the most abundant cation in body fluids (Figure 1), supplementation is usually not necessary unless horses have been off feed for several days or have been on fluid therapy for more than 48 hours. In these instances, depletion of total body K^+ stores can be substantial yet serum K^+ may still be within the normal range because < 0.5% of exchangeable K^+ is in plasma. Again, with prolonged support (> 48 hours) with fluids designed for rehydration, excessive replacement of body Na^+ stores will increase urine output and further exacerbate K^+ depletion by increasing obligate K^+ loss in urine. Assuming that the fluid therapy plan at the time a decision to add K^+ is made is to administer about 35 liters of intravenous fluid over the subsequent 12 hours (1 liter/hour for maintenance and 2 liters/hour for anticipated losses in diarrhea, after rehydration has been accomplished), only about 175 mEq of K^+ would be replaced using a typical polyionic crystalloid fluid. This would represent replacement of < 1% of body K^+ stores at the same time that urine K^+ losses could result in further depletion of as much as 3–4% of body K^+ stores through production of 10 liters of urine (~ 3-fold increase in urine flow due to a Na^+ diuresis) with a K^+ concentration as low as 100 mEq/L. To simply match this estimated urine K^+ loss, 25 mEq of additional K^+ would need to be added to each of the 35 liters of fluid administered. As can be seen, addition of 20 mEq/L of K^+ per liter of fluid, usually in the form of KCl, is generally safe and is often of benefit to horses receiving fluid support for more than a couple of days. An alternative to adding KCl to the intravenous fluids is to administer KCl in enteral fluids or as an oral paste. For example, to provide 1500 mEq of KCl daily (≈ 5% of body K^+ stores), 110 g of KCl (1 g of KCl provides 13.4 mEq of both K^+ and Cl^-) could be administered as 4 doses of 25–30 g KCl via a nasogastric tube or as an oral paste.

Although not a specific additive to a base fluid, 1–2 liters of hypertonic saline (7.5% NaCl solution) is sometimes administered intravenously concurrent with isotonic crystalloid fluids during initial rehydration. Hypertonic saline has Na^+ and Cl^- concentrations of 1285.2 mEq/L or an osmolality of 2565 mOsm/kg, a value ~ 9-fold greater than plasma. The goal of administering hypertonic saline is to transiently draw water by osmotic forces into the plasma space from the interstitial space and ICF. This treatment is ideally suited for horses experiencing rapid fluid loss from the vascular space resulting in shock (i.e., hemorrhagic shock) but can also be useful in patients that have hypovolemic shock as a result of other types of fluid loss. In both types of shock, administration of hypertonic saline may stimulate drinking but close patient monitoring is warranted because critically ill patients may not respond as expected. A further use for hypertonic saline is in patients that have moderate to severe electrolyte depletion in the face of only mild to moderate dehydration. Examples include horses that have performed long distance exercise (with substantial sweat fluid loss) or that have had diarrhea for several days. In both instances, voluntary drinking may have replaced 50% or more of water loss yet this form of fluid replacement is not accompanied by replacement of electrolytes.

Electrolyte Administration as Oral Pastes or in Drinking Water

Use of oral electrolyte pastes the advantage of replacing needed electrolytes without placing additives in the base intravenous fluid (increasing osmolality and cost) and limiting the number of times that a nasogastric tube has to be passed. However, when they are used to complement the fluid therapy plan, it is important to ensure that horses also drink water in the hours after electrolyte administration. In fact, for some horses with mild to moderate dehydration (3–7%), it is reasonable to initially treat horses with a dose of enteral fluids (10 liters via a nasogastric tube would correct ~ 2% dehydration) and oral electrolyte pastes. Because the goal of electrolytes administered orally would be to stimulate further drinking, NaCl should be the predominant electrolyte administered and it can be given alone or mixed with KCl in a ratio of 2:1 to 3:1. As for enteral fluids, oral pastes can be made from table salt and lite salt (a 1:1 mixture of NaCl and KCl).

Administration of 30 g of NaCl (~ 500 mEq of Na^+ and Cl^- [1 g of NaCl provides ~ 17.1 mEq of both Na^+ and Cl^-]) as an oral paste provides an amount of NaCl similar to that in 3–4 liters of an isotonic polyionic crystalloid fluid. Thus, dosing oral pastes at 6-hour intervals should provide a similar amount of electrolytes as a maintenance rate of intravenous fluids and more frequent administration could be used to replace electrolytes lost by disorders producing dehydration. Again, use of oral electrolyte pastes will only be beneficial if horses voluntarily drink water to replace the concurrent water need. Although use of oral pastes has both practical (e.g., can also be administered by a client on the farm) and economic advantages, their administration may be accompanied by transient interruption of feeding, apparently due to poor palatability of the pastes. In an attempt to lessen this problem, salts can be mixed with corn oil, molasses, applesauce, or yoghurt rather than water. A final option to increase electrolyte intake is to dissolve NaCl and KCl in drinking water. Adding 30 g of NaCl, or a mix of NaCl and KCl, to each gallon of drinking water would make a nearly isotonic solution that may be consumed by some horses.

However, voluntary drinking of water containing electrolytes is variable between horses; thus, plain water should also be made available in addition to water containing electrolytes.

Monitoring Response to Treatment

Response to fluid therapy is practically monitored by reassessing the patient's attitude and clinical parameters of hydration, including heart rate; moistness of oral membranes; temperature of the nose, ears, and extremities; skin tent response; PCV; and TS. In addition, an obvious, but easily overlooked, assessment is the frequency of urination. Most horses should be observed to pass dilute urine within 6–12 hours after onset of fluid administration and horses with mild dehydration (5–7%) may start to pass urine within 2 hours. Once an increase in urine output is observed, the rate of fluid administration can usually be reduced. At times, improvement in other clinical parameters (e.g., heart rate or PCV) is less than desired despite increased urine output. Rarely does maintenance of a high fluid administration rate correct these clinical abnormalities once urine output has increased. More often, patients may need further treatments to increase oncotic pressure (e.g., plasma or hetastarch) or provide better analgesia for the underlying disease.

Discontinuation of Fluid Therapy

It is often easier to decide when a horse needs fluid therapy than to determine when it can be discontinued. Nevertheless, there are a couple of rules that can be followed. First, the medical or surgical problem being treated should be stable or improving for 12–24 hours before discontinuation of fluid therapy. This would include correction of dehydration and at least 6–12 hours of fluid administration at a maintenance rate alone. Fluid therapy does not necessarily have to be continued until all laboratory data, including serum electrolyte concentrations and measures of renal function, have returned to the normal ranges. This is especially true for horses that are improving in response to treatment. Second, when the medical or surgical disorder has been accompanied by partial or complete anorexia, a reasonable goal is for the horse to be eating at least 50% of a normal feed ration, preferably with an increasing appetite, before fluid therapy is discontinued. There are obvious exceptions to this rule; for example, a horse being treated for impaction colic with enteral fluids (via a nasogastric tube) will usually not be offered feed until after the last dose of enteral fluids has been given. The main point of this rule is that fluids do not need to be continued until the patient is back on full feed. Third, a more cautious approach to discontinuing fluid therapy should be considered in horses receiving multiple potentially nephrotoxic medications (e.g., gentamicin and flunixin meglumine or phenylbutazone), especially if indices of renal function are above the normal ranges.

The decision to discontinue fluid therapy is more difficult in patients with long-standing (> 5 days) ongoing fluid losses such as persistent gastric reflux with small intestinal disorders or persistent diarrhea in more severe cases of enterocolitis. These types of cases may also be receiving multiple intravenous infusions (e.g., partial or total parenteral nutrition, lidocaine, etc.) in addition to maintenance fluid support. In fact, when all the fluids being administered are added up, these patients are often receiving fluid at a rate greater than maintenance needs. Once considered stable, the approach should be to "challenge" these patients, by discontinuing fluid therapy for 12–24 hours. If their clinical condition deteriorates (e.g., a decrease in appetite; greater lethargy; and increases in heart rate, PCV, and TS), fluid therapy can be started again. With more serious disorders, horses may need to be challenged by having fluid therapy discontinued several times before they can remain stable.

References

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