Fluid Administration to Dehydrated Calves

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Abstract

Fluid therapy can be a pivotal component of the treatment plan for calves with diarrhea, respiratory disease or any other health problem that results in reduced fluid intake or accelerated loss from the body. Daily fluid requirements in health and disease are described. Using clinical case examples, an approach to patient evaluation and fluid requirements is described. Routes of fluid administration, components of fluid loss and the types of fluid available to resuscitate and rehydrate calves are discussed and applied.

Introduction

Fluid therapy is well recognized as the pivotal component of the treatment plan for calf diarrhea. Fluid administration can also be an essential component of the supportive care given to calves with other conditions like respiratory disease. While fluid loss from the body is the main cause of dehydration in neonatal calf diarrhea, decreased fluid intake and increased metabolic rate are other important components of fluid imbalance in sick calves. On a percent basis, newborn calves have a higher total body water content and extracellular fluid compartment than adults. Despite the larger fluid compartments, there is enhanced susceptibility with little protective effect against dehydration during episodes of diarrhea.[1]

Fluid homeostasis in calves is necessary for metabolism and transport of nutrients, as well as digestion, absorption and elimination of wastes. The ingestion of milk or milk replacer and water balances the normal fluid loss that occurs in calves through urine, feces, the respiratory tract and skin. The daily water requirement (approximately 10% of body weight) is not met solely by milk intake after the first few days of life, and supplemental water is a requirement. A normal 88 lb (40 kg) calf requires 4 L (approximately 1 gallon) of water daily, which is not supplied by 4 L of whole milk or milk replacer. With illness, calves have reduced intake, enhanced metabolic needs and accelerated losses that can lead to severe dehydration. Calves with diarrhea, for example, may lose 10-15% of their body fluids daily. Untreated, dehydration and the associated acid-base and electrolyte disturbances result in depression, weakness, hypothermia, shock, organ dysfunction, coma and death. The purpose of this paper is to use clinical examples to illustrate some principles of rehydration therapy of calves.

Clinical Cases

Calf 1: This is a two-week-old Holstein heifer calf that has had diarrhea for one week. Many calves in the herd have been similarly affected and *Cryptosporidium parvum* is believed to be a contributing factor. The calf is thin (81 lb; 37 kg) and weak, with a wet, soiled tail and perineal area. She passes profuse, watery diarrhea but demonstrates an interest in suckling. Her eyes are slightly sunken (4-5 mm) and a skin tent made on the neck lasts for six seconds.

Calf 2: This is a comatose three-day-old, 94 lb (43 kg) Charolais heifer calf. She nursed well when last observed approximately 10 hours earlier but is now recumbent, unresponsive and cold. Eyes are markedly sunken within the orbit and cervical skin tent duration is greater than seven seconds. No diarrhea has been observed. (Rule out hypoglycemia, E/Se, heart defect)

Calf 3: This nine-day-old, 103 lb (47 kg) Holstein calf has had diarrhea for two days. The owner has given the calf oral electrolyte solution since diarrhea developed, but now she won't suckle and her abdomen is distended. She is depressed; her mouth is dry and cold. There is no obvious retraction of the eye but a skin tent persists for five seconds. Feces are loose, with blood and fibrin casts present.

Evaluation and Assessment of the Dehydrated Patient

Prior to fluid administration, obtain body temperature, heart rate, and respiratory rate. Note fecal consistency, presence of gastrointestinal activity and abdominal size. Estimate the degree of dehydration as mild, moderate or severe. The signs of mild dehydration may be limited to dry mucous membranes, cold extremities and cervical skin tent duration of two to four seconds, but moderate and severe dehydration will be more easily recognized by progressive retraction of the eyeball within the orbit. Dehydration can progress from mild to severe very rapidly in acute conditions, especially in very young animals, so estimates should err on the side of giving more fluids rather than less.

- **Severe dehydration** is present when calves have > 5 mm recession of the eyeball into the orbit, when a skin tent made in the loose skin of the neck persists for ≥ seven seconds and mu-

cous membranes of the mouth are dry and cold.[3] If isotonic or hypotonic fluids are chosen, administration of a minimum of 4.5 L to a 99 lb (45 kg) calf is required to resolve the severe dehydration.

- **Moderate dehydration** is present when there is visible recession of the eyeball into the orbit but it is less than 5 mm. Skin turgor is reduced and a skin tent created in the loose skin of the neck persists for six to seven seconds. Mucous membranes of the oral cavity are dry and cold. Correction of the dehydration with isotonic or hypotonic fluids will require a minimum of 3.6 L to a 99 lb (45 kg) calf.
- **Mild dehydration** is assumed to be present when calves have not eaten or have had reduced water intake for 24 hours or more. These animals are depressed, mucous membranes are tacky and the nose may be drier than normal. A skin tent is sluggish but persists ≤ to five seconds. There is no visible recession of the eyeball within the orbit. Treatment of mild dehydration requires administration of a minimum of 2.5 L of isotonic or hypotonic fluids to a calf.

To calculate the fluid requirements to correct dehydration, a percent dehydration is assigned to the clinical signs discussed above. For calves with severe dehydration, estimates of 12-14% are used to make fluid calculations. Moderate and mild dehydration are 8-10% and 4-6%, respectively. Applied to the cases above, calf #1 is moderately dehydrated and requires 3.0 L (8% X 37 kg bw = 2.96 L) of fluid for rehydration. Calf #2 needs 5.2 L (12% X 43 kg bw = 5.16 L) while calf #3 needs 2.8 L (6% X 47 kg = 2.82 L). Calculation of fluid requirements to correct dehydration should recognize that if fluid administration is not accompanied by voluntary drinking, an additional daily requirement of 80 ml/kg body weight in L of fluid should be added. For calves with ongoing fluid losses due to diarrhea, the additional daily fluid requirement is estimated at 45 ml/lb (100 ml/kg) body weight in L of fluid.

Route of Fluid Administration

The choice of route of fluid administration may be dictated by medical parameters such as degree of dehydration, gastrointestinal tract function, or concomitant medical disorders such as toxemia or sepsis. Moreover, the route of fluid administration may be chosen based on non-medical factors like personnel experience, time, availability of care, restraint facilities, product availability and economics. For the purpose of this paper, discussion is limited to choices of intravenous, oral or combined intravenous and oral fluid administration. The author recognizes that subcutaneous and intraperitoneal fluid administration can benefit dehydrated animals. The latter routes of fluid administration may, however, limit fluid choices, volume, rate of delivery and absorption. Diarrheic calves needing fluid, electrolyte or energy support have the same requirements regardless of the route of administration. Regardless of the route of fluid administration, dehydrated calves should have access to fresh water.

- The **intravenous fluid route** is used to administer hypertonic saline or isotonic fluids when there is severe dehydration, abdominal distension, gastrointestinal obstruction (functional or mechanical), hypothermia, ileus, recumbency or coma. The IV route is preferred when there is toxemia or sepsis. Experienced personnel may choose this route over other routes when products, facilities, labor and monitoring capabilities are ideal, regardless of the severity of dehydration.
- **Oral fluids** are a cost-effective means to rehydrate cattle with mild or moderate dehydration as long as there is some evidence of gastrointestinal motility (borborygmus and fecal output). Candidates for oral rehydration should be able to stand without assistance, exhibit some evidence of a suckle reflex and have no abdominal distension. Commercial oral fluid rehydration products should be precisely mixed as directed by the product label.
- **Combined IV resuscitation (hypertonic or isotonic fluids) followed by oral fluid therapy** is a practical approach to rehydration therapy on the farm or when long-term restraint is not practical. An initial intravenous fluid bolus in the form of hypertonic saline, dextrose, isotonic sodium bicarbonate solution or warm polyionic fluids may provide enough resuscitation or stimulus for calves to drink on their own and/or to regain enough gastrointestinal function to be candidates for ongoing oral fluid administration.

For calf #1, although dehydration is moderately severe, the calf is standing and willing to suckle. Its condition is chronic (one week in duration) so compensatory changes in acid-base balance and oxygen delivery to tissues should not be suddenly reversed by rapid administration of fluids. Moreover, the calf is ambulatory and restraint for IV infusion will be more difficult. For these reasons, oral rehydration is a practical solution. The calf requires 3 L of fluid for rehydration, another 4 L for maintenance fluids and approximately 1 L for ongoing losses due to diarrhea. Four liters of an oral

electrolyte solution and 4 L of milk replacer will satisfy the 24-hour fluid demands for this patient. To maximize chances of absorption of nutrients and fluids, the calf will be given four feedings in a 24-hour period. At each feeding, 1 L of milk replacer is offered first, followed by 1 L of oral electrolyte solution (OES). An alternative approach is to offer two feedings (2 L each feeding) of milk replacer and two feedings (2 L each feeding) of OES.

Calf #2 is comatose so fluids for resuscitation and rehydration must be administered intravenously. Though undetermined at this time, the coma could be due to severe hypothermia, hypoglycemia, septicemia, meningitis, acidemia and/or dehydration. When possible, IV fluids should be warmed. The calf needs 5.2 L of fluid for rehydration. Rehydration fluids are administered after a 5 gm bolus of IV dextrose and 150 ml (4-5 ml/kg bw) of hypertonic saline solution is given to the calf over a five-minute period. From the presenting clinical status, it should be anticipated that longer-term fluids as well as antibiotics might be needed. For that reason a long term, double-lumen catheter (Mila International, Inc.) is sutured in place in the jugular vein. Jugular venous catheterization, while challenging in severely dehydrated calves, is facilitated by placing the calf in lateral recumbency on an elevated surface and draping the head and neck over the edge in a dependent position. To facilitate catheter introduction, make a small incision in the surgically prepared skin over the distended jugular vein.

Calf #3 is not severely dehydrated, but its condition has deteriorated despite oral fluid therapy and there is abdominal distension present. This calf requires 2.8 L of fluid for rehydration, 5 L for maintenance and approximately 1 L for ongoing diarrheic losses in the next 24 hours. Either a short-term over-the-needle IV catheter (Mila International, Inc.) or a long-term, single lumen catheter (Arrow International, Reading, PA) could be used in this calf. The appearance of the diarrhea and herd history is compatible with salmonellosis, so antibiotics and fluids will be needed. Maintenance of a functional IV catheter will provide an effective route for antibiotic therapy, so a long-term catheter is sutured in place. To facilitate movement of the calf during IV fluid therapy, an extension set is added to the fluid line and the calf is outfitted with a gauze surcingle through which the IV line courses.

Components of Fluid Losses

Diarrhea in young calves is associated with fecal losses of water, sodium, potassium, chloride and bicarbonate. Prior to treatment, diarrheic calves typically develop metabolic acidosis and hyperkalemia. Serum hyperkalemia is misleading because there is total body potassium depletion due to fecal loss and decreased intake. Despite the presence of serum hyperkalemia, potassium-rich fluids are used. Acute diarrhea, septicemia and/or toxemia may result in profound hypoglycemia in newborn calves. Sick calves housed in cold housing are at increased risk of being hypoglycemic with illness. Newborn calves have very little body fat on a percent basis and the brown fat that they have is used for body heat generation rather than for energy. Bicarbonate concentration is usually low while chloride concentration is normal or slightly elevated in diarrheic calves. Prior to intervention, sodium concentration may be low or normal. Calves that have already received oral electrolyte solutions, have been fed a high sodium milk replacer and/or have limited access to water may be hypernatremic. Most diarrheic calves have normal kidney function and therefore the focus of fluid therapy is rehydration. With rehydration, electrolyte and acid-base balance are usually corrected relatively rapidly, provided balanced electrolyte solutions are provided. If reduced intake in calves is the primary reason for fluid therapy, water and potassium are the focus of supplementation.

The risk of hypoproteinemia due to inadequate colostrum consumption, poor colostrum absorption or intestinal protein loss (salmonellosis) requires that serum protein and albumin concentrations be monitored in calves undergoing rehydration therapy.

Fluid choices

Fluid choices for calves can be classified as isotonic or hypertonic, balanced or unbalanced, crystalloid or colloid, alkalinizing or acidifying. Balanced, isotonic, alkalinizing fluids are appropriate for most uses in calves. Isotonic fluids, which have a sodium concentration that mimics plasma levels at approximately 140 mEq/L and an osmolality of approximately 300 mOsm/L, are designed to restore or maintain extracellular fluid volume. By contrast, hypertonic solutions like 7.2% NaCl have an osmolality of 2400 mOsm/l and are designed for rapid plasma volume expansion that is needed for resuscitation, rather than rehydration. While 1.3% sodium bicarbonate solution is considered isotonic at 310 mOsm/L, the sodium concentration is 155 mEq/L and can lead to hypernatremia if it is used as the only rehydration fluid. Similarly, normal saline solution, while isotonic, has a sodium concentration higher than plasma and may exacerbate existing hypernatremia. Hypertonic bicarbonate solutions or any other unbalanced electrolyte solution administered to calves greatly increase the chances of hyperosmolar syndrome and hypernatremia. Crystalloid solutions are made up of electrolytes and organic compounds like dextrose or lactate that form a solution and distribute in all body compartments. Colloids, on the other hand, are high molecular weight substances that cannot pass through a semi permeable

membrane and are added to fluids to sustain plasma volume expansion. Plasma and dextran solutions are the colloid solutions most commonly given to calves that are hypoproteinemic.

Bovine practitioners have access to a number of commercial parenteral and oral rehydration solutions.[2,5,6] Because of this product availability, there is limited need for custom-made rehydration solutions to be used in calves. The primary goal of fluid therapy in calves is rehydration. Prompt attention to rehydration by accurate calculation and administration of total fluid volume requirements (maintenance + rehydration + ongoing losses) will obviate the need for expensive laboratory monitoring, minimize the chance of developing severe electrolyte abnormalities and restore acid-base balance in sick calves. Some appropriate parenteral fluids choices for calves are Normosol-R (Abbott) and Plasmalyte-R (Baxter), which are alkalinizing and have sodium, potassium and chloride concentrations that resemble plasma. Additional potassium is usually added to achieve a final concentration of 10-20 mEq/L. Early in the course of treatment, dextrose supplementation at a rate of 10-20 g/L fluids (1-2%) of IV fluid infusions is advisable. Sick calves usually receive 4 L of IV isotonic fluids for rehydration, administered over a four-to-six hour period and prior to changing to oral electrolyte therapy. Calves that fail to respond positively to 4 L of IV fluids should be subjected to a detailed physical examination, evaluation of acid-base balance, measurement of glucose and electrolyte concentrations.

Oral fluid therapy as the primary rehydration protocol is practical, efficient, economic, and can be very effective in mild to moderately dehydrated calves. The best oral electrolyte products are those that are alkalinizing, balanced in their electrolyte composition, have a sodium concentration that does not exceed 140 mEq/L, and are isotonic or slightly hypertonic. Calves that fail to respond or deteriorate within 24 hours of initiation of therapy should be subjected to a detailed physical examination, evaluation of acid-base balance, measurement of glucose and electrolyte concentrations.

Intravenous hypertonic saline administration is an appropriate alternative for the isotonic or hypotonic fluid volumes described above for treatment of dehydrated calves. The protocol for IV hypertonic saline administration is 4-5 ml/kg (2,400 mOsm/L) over four to five minutes.[4] For calves, 120-200 ml of hypertonic saline is administered. Immediately after administration, consumption (voluntary, forced or a combination of both) of 2 to 4 L of isotonic or hypotonic oral electrolyte solution is appropriate for calves.

Summary

Fluid therapy is advised in sick calves with mild, moderate or severe dehydration and can be provided to calves in an efficient and cost-effective manner. To correct dehydration, an appropriate volume of fluids must be administered intravenously, orally or by combined IV and oral routes of fluid administration. For calves, mild, moderate and severe dehydration can be resolved by administration of 2, 3 or 4 L of isotonic, balanced electrolyte fluids. For more severe dehydration, IV fluids with potassium and dextrose supplementation are appropriate. Many commercially available oral electrolyte solutions are suitable for rehydration of diarrheic calves, provided that fluids supplement, rather than replace, the normal daily requirement of approximately 4 L of fluid intake. Hypertonic saline solution is useful as a resuscitation fluid for moribund calves and can be followed by oral or IV balanced electrolyte solutions. Successful implementation of fluid therapy protocols requires the development and communication of clearly articulated protocols with defined guidelines for volume, route and choice of fluid administration. Trained personnel must understand and share expectations of the fluid therapy plan, have appropriate monitoring of patients and records and receive constructive feedback from regular review of records, number of patient treatments, and outcomes.

References

1. Berchtold J: Intravenous fluid therapy of calves. *Vet Clin North Am Food Anim Pract* 15(3):505-531, 1999.
2. *Compendium of Veterinary Products,* ed 7. North American Compendiums, Ltd. Port Huron, MI, 2003.
3. Constable PD, Walker PG, Morin DE, *et al*: Clinical and laboratory assessment of hydration status of neonatal calves with diarrhea. *J Am Vet Med Assoc* 212(7):991-996, 1998.
4. Constable PD: Hypertonic saline. *Vet Clin North Am Food Anim Pract* 15(3):559-585, 1999.
5. Naylor JM: Oral electrolyte therapy. *Vet Clin North Am Food Anim Pract* 15(3):487-504, 1999.
6. Nieuwoudt CD: Parenteral electrolyte replacement solutions. *Vet Clin North Am Food Anim Pract* 15(3):669-677, 1999.