Water Loss & Diarrhea

From Electrolyte & Water Balance in Calves
Developed by Rob Costello, Technical Specialist

Pathogens, feed characteristics and management influence digestive function and can result in water loss through the digestive tract. There are four types of digestive water loss. Each is defined in this section. A diarrheic animal may actually suffer from more than one type of water loss at the same time. The process of dehydration and the clinical signs associated with progressive water loss in calves are also discussed.

Types of Water Loss Associated With Diarrhea

Increased Permeability. Microbes cause inflammation and damage to the intestinal mucosa resulting in increased water movement into the intestine. This type of water loss is commonly caused by viruses (rotavirus, coronavirus) and protozoa (coccidia, cryptosporidia). Inflammation may also lead to hypersecretion.

Hypersecretion. This type of water loss is similar to increased permeability in that large amounts of water move into the intestine, but there is no tissue damage. Bacterial enterotoxins stimulate cellular pumps in the crypt cells of the intestinal mucosa to secrete large amounts of ions into the intestinal lumen. These ions draw water into the small intestine. These mechanisms were previously described in Figure 4. Hypersecretion in calves is most commonly caused by *E. coli.*

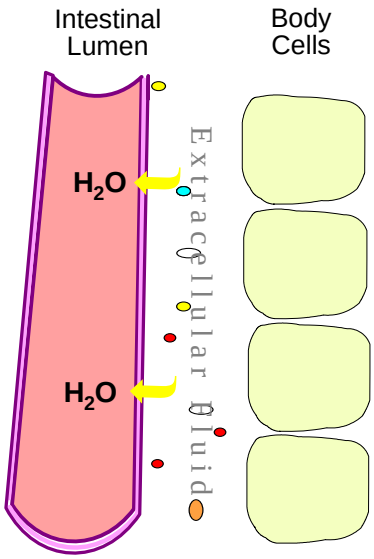
Malabsorption. Epithelial damage in the small intestine reduces nutrient absorption. Viruses and protozoa damage the villi in the small intestine leading to villous atrophy, and can damage the large intestinal mucosa as well. Normal amounts of water may be secreted into the digestive tract, but tissue damage results in poor nutrient and water absorption. Malabsorption causes nutrients to bypass absorption in the small intestine. As these nutrients reach the large intestine, they can cause bacterial overgrowth and excessive production of volatile fatty acids (VFAs). As a result, osmotic changes occur that worsen fluid loss.

Maldigestion. Changes in feed management may lead to maldigestion. A sudden change in feed, use of poor quality ingredients, the presence of feed allergens or other detrimental feed factors, and digestive disorders can lead to maldigestion. Maldigestion usually results in malabsorption.

Dehydration

During diarrhea, large amounts of water and electrolytes are lost from the body. Water moves from the extracellular fluid (the blood and the interstitial space between cells) into the intestinal lumen. Figure 14-A.

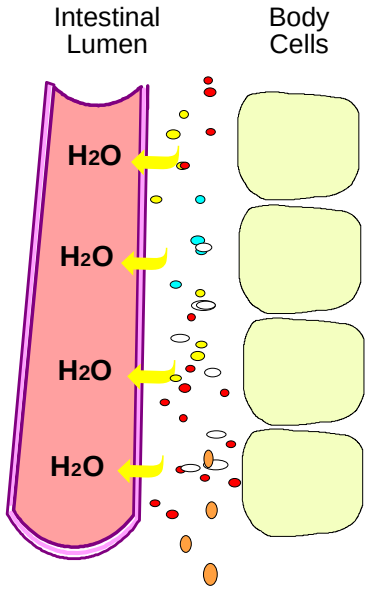
Figure 14-A. Process of Dehydration Due To Scours



14-A

As more and more water moves into the intestine, the concentrations of ions and other substances in the extracellular fluid rises resulting in a hypertonic solution. Figure 14-B. As a result, osmotic pressure within the extracellular fluid

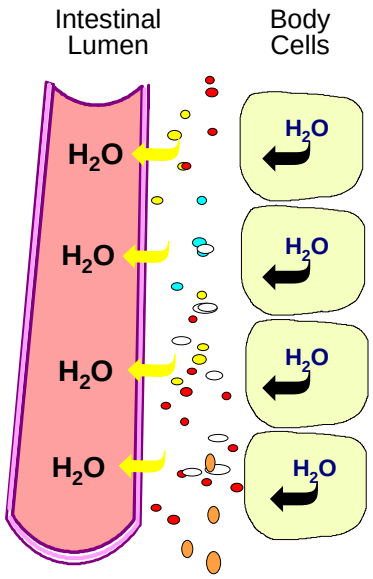
Figure 14 B.



14-B

increases. Since water moves toward areas of high osmotic pressure, water leaves the surrounding cells and moves into the extracellular fluid. Figure 14-C. This movement of water out of the cells increases the volume of the extracellular fluid and lowers its osmotic pressure. As body cells lose water they become dehydrated. This process of cellular dehydration helps maintain blood volume.

Figure 14 C.



14-C

Figure 14-D.

Hypertonic, Hypotonic and Isotonic

"Tonic" refers to the concentration of substances in a liquid relative to that found in normal plasma. Hypertonic describes a liquid that contains more solutes and less water than plasma. Hypotonic means a solution with fewer solutes and more water than plasma, and an isotonic solution has similar concentrations of solutes and water to those found in normal plasma.

The hypertonic situation is described above for water lost through the digestive tract. It is also an appropriate description of dehydration resulting from sensible water loss through respiration and body temperature regulating mechanisms during periods of heat stress and reduced water intake.

A hypotonic situation can arise when large amounts of electrolytes etc. are lost from the extracellular fluid into the intestinal lumen relative to water loss. This results in an increasing proportion of water remaining in the extracellular fluid, thereby reducing its osmotic pressure. Since the osmotic pressure within the cells is now greater than the surrounding fluid, cells retain their water. Additional water may actually be drawn from the extracellular fluid into the cells during hypotonic water loss.

Isotonic water loss occurs when the same relative proportions of water, electrolytes and other solutes are lost from the extracellular fluid into the digestive tract as are normally found in plasma. Since there are no osmotic gradients created in this situation, water would not tend to flow from one body compartment in response to osmotic changes.

Practically speaking, it is difficult to ascertain the specific tonicity involved in an episode of diarrhea without analytical equipment.

As dehydration progresses, tissues tend to shrink, skin becomes dry and wrinkled, and eyes become shrunken and soft. Fever develops as

dehydration worsens. If water loss continues and plasma volume falls, the kidneys reduce urine output in order to conserve water. As urine output decreases, waste products accumulate in the blood.

Reduced kidney function causes changes in plasma ion concentrations and a reduction in plasma pH. As pH is reduced, acidosis occurs. Both dehydration and acidosis interfere with the animal's ability to maintain its body temperature and lead to hypothermia. The animal's attitude and posture are related to the severity of these factors. Table 1.

Acidosis is more severe in older calves and may contribute more to depression and weakness than in younger calves. As shown in Table 1, the plasma ion deficit of older calves is more severe than younger calves showing the same clinical signs. *E coli* infections are most common in calves under one week of age and tend to cause hypersecretion diarrhea with rapid and severe water loss. The speed with which dehydration occurs during these infections may not provide enough time for the lungs to compensate for the rapid onset of acidosis. As a result, dehydration rather than acidosis may be more related to attitude and posture in younger calves. Respiratory compensation is consistent with prolonged metabolic acidosis, and could be the reason older calves present a more severe acidosis in each category (Naylor, 1987)

As water loss reaches about 8 - 10% of body weight, blood viscosity increases causing a decrease in cardiac output and a rise in pulse rate.

As water loss continues, acidosis progresses, lowering plasma pH to the point that cell membranes start to depolarize. Potassium begins to leave the cells and increases in the extracellular fluids. The reduced membrane potential interferes with muscular contractions, causing the heart to beat irregularly. Blood pressure decreases resulting in circulatory failure and reduced blood flow to the lungs. The pulse weakens and the calf goes into an irreversible shock and becomes comatose. Death results from heart failure.

Table 1. Relationship Between Metabolic Acidosis And Clinical Signs In Calves

Category	Weight Loss	Clinical Signs	Severity of Acidosis By Age (mmol/l)*	
			≤8 days	>8 days
1	4-6%	no clinical signs,stands without assistance strong suckling reflex	0	5
2	6-8%	weak but able to stand, weak suckling reflex, dry mouth and nose, tight skin, sunken eyes and depression	5	10
3	8-10%	calf resting on its sternum, above signs more pronounced, depression more severe	12	16
4	10-14%	calf in lateral recumbency, cool extremities, poor peripheral pulse, comatose	13	20

*This is the plasma base deficit and represents how far away a calf is from the normal acid base balance of zero

Source: adapted from J.M. Naylor, Can Vet J. 1989, 30:577-580

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