Neo-Natal Diseases

Chairman: Dr. Lloyd Faulkner, Ft. Collins, Colorado

Diarrhea in the Calf
Part I: Pathophysiologic Changes and Development

Diarrhea in the Calf
Part II: Secondary Changes and Treatment

Therapy In Practice

Diarrhea in the Calf
Part I: Pathophysiologic Changes and Development*

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Before effective management and therapy can be initiated for neonatal diarrhea we must understand normal intestinal function as well as the changes that take place in the intestinal tract leading to the diarrhea. Of even greater importance is a knowledge of secondary and tertiary changes which occur as a result of the altered intestinal transport. First, let us review normal intestinal function in the calf. Milk by-passes the rumen or reticulum and is coagulated by rennin and the acid conditions of the abomasum or true stomach (7). As proteolytic enzymes act, the curd is liquefied and passes into the duodenum where further enzymatic activity breaks down the proteins, carbohydrates and lipids. In the jejunum these organic compounds are absorbed as the fatty acids, amino acids, and sugars (4). There is also considerable secretory activity here and some absorption of electrolytes, although the majority of the electrolytes are absorbed further down the intestinal tract in the lower jejunum and ileum (4). Final absorptive function occurs in the upper portion of the colon where feces are normally formed.

In a typical intestinal cell there are a number of membrane transport systems which act in concert to move nutrients from the gut lumen to the capillaries and lacteals of the intestinal villi (8). Our concern, diarrhea, occurs when these transport systems fail to function normally (1,17,18). Let us consider the changes that occur when a pathogen disrupts these transport systems. In a normal section of intestine there is a movement of fluids in both directions across the mucosae, both secretion and absorption continuously occur. In general, most of the fluid secretion occurs in the upper portion of the small intestine. During diarrhea, when transport systems are altered, there may be an increased rate of secretion bringing electrolytes into the intestinal lumen (2,18). The osmotic gradient which results causes water to move in the same direction. There is generally a decrease in

*Supported in part by Western Regional Experiment Station Project W112 and Special Research Fellowship (FO3 GM 45100-01) to L.D.L. from the National Institutes of Health, General Medical Sciences.

absorption which leaves not only electrolytes and water but the organic nutrients, carbohydrates, fats and proteins in the intestine (1,10,17). Recall that these latter substances are ordinarily absorbed in the upper jejunum. When absorption fails, bacteria begin to utilize the unabsorbed nutrients, producing organic acids and migrating anteriorly. Bacterial growth and migration may result in secondary complications of a primary viral diarrhea (16). In addition to increased secretion, decreased absorption and increased bacterial movement and growth, there is a fourth consequence of diarrhea which commonly occurs; a decrease in gut motility (14,15). This is to many a surprising occurrence as one usually associates increased motility with an increased rate of fecal passage. However, in most cases of infectious diarrhea in man and animals, gut motility is restricted. These common intestinal alterations are shown in Figure 1.

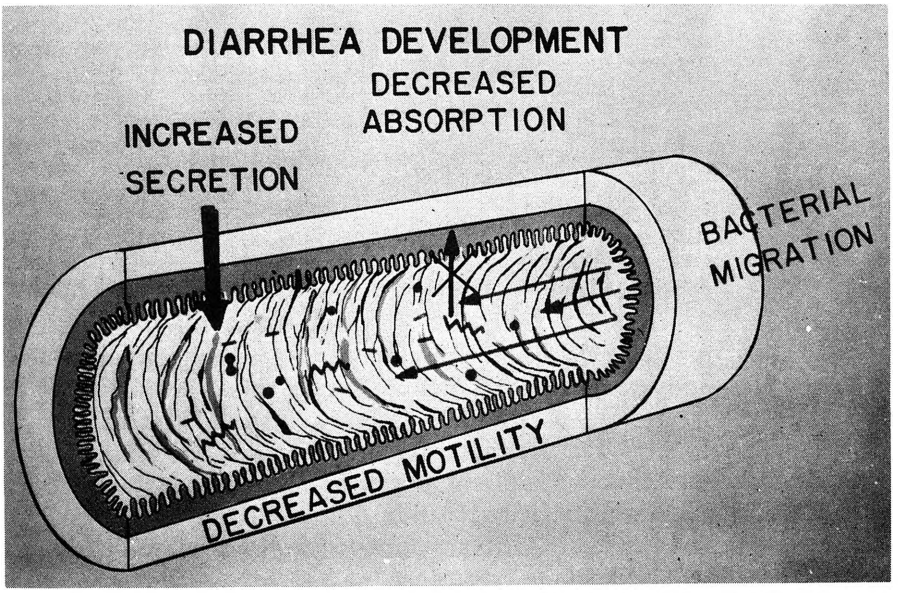

Figure 1: Intestinal alterations as a result of diarrhea. Either or both increased secretion and decreased absorption may occur. There is generally an increase in bacterial colonization and a decrease in motility.

This then is how diarrhea develops, but what is lost? Meaningful replacement therapy must be based upon a knowledge of both the calves' requirements and the diarrheal losses. Truly the changes in water and electrolyte balance during diarrhea are immense. A normal, healthy, growing calf will gain body water at the rate of 22 ml/kg/day while during diarrhea water is lost as rapidly as 72 ml/kg/day (11,13). Considered from another point of view there is a 28-fold increase in water loss during diarrhea (13).

What about electrolytes? Figure 2 illustrates the quite marked change in the net gains or losses of Na^+, K^+, Ca^{++}, Mg^{++}, Cl^- and HCO_3^- observed as diarrhea develops (3,9). Sodium is normally in slight

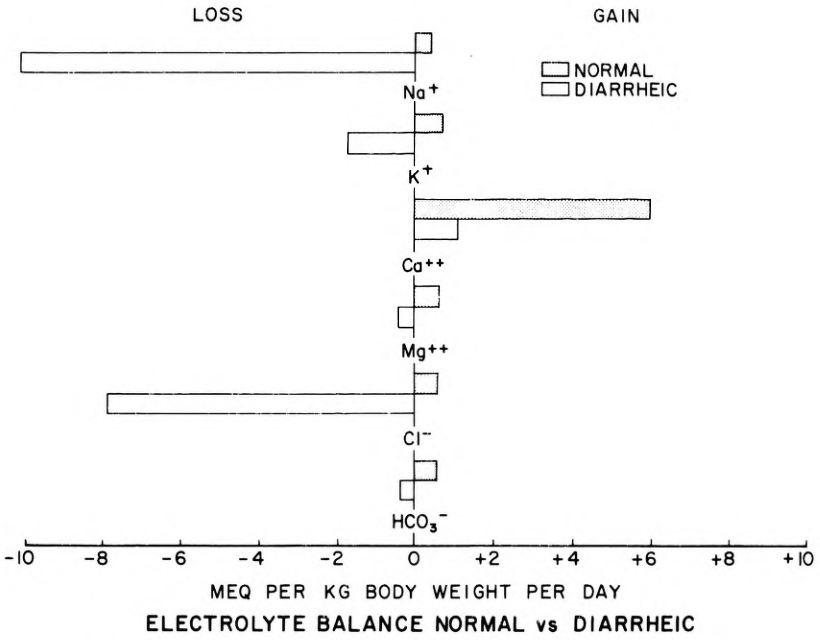

Figure 2: Electrolyte balance during acute infectious diarrhea in calves.

positive balance but becomes a very severe loss during diarrhea, and large quantities of Na^+ leave the body. The losses, although less for K^+, still represent a significant change in body composition. We find that it is in greater positive balance in the normal calf which indicates that most of the body substance gained in the growing animal is of an intracellular nature, as K^+ is the primary intracellular action. In contrast, the loss of Na^+ during diarrhea is indicative of a primary extracellular fluid loss. As we would anticipate in a growing milk fed calf, Ca^{++} is in a strong positive balance. Calcium is the only ion which has a net gain during diarrhea although it is greatly decreased from the normal state. Gain of Mg^{++} during normal intestinal function is reversed in diarrhea with losses nearly equal to the normal gain.

There is a very large loss of chloride in diarrhea. The relationship between chloride and sodium is quite similar, which is not surprising as they, in essence, constitute the extracellular ions. Bicarbonate loss is roughly equivalent to HCO_3^- gain under normal conditions. The loss of bicarbonate is more important than it would seem on the basis of this comparison as HCO_3^- loss without a concomitant H^+ loss is one of the major factors contributing to the developing acidosis which is so marked in diarrhea (5,6,12). These losses as a result of the altered intestinal function lead to the secondary alterations which cause debilitation and death of the diarrheic calf.

Let us consider the distribution of body water under normal conditions (Fig. 3). Approximately 55% is intracellular and 45% extracellular. Eight percent of the body water is in the plasma. During

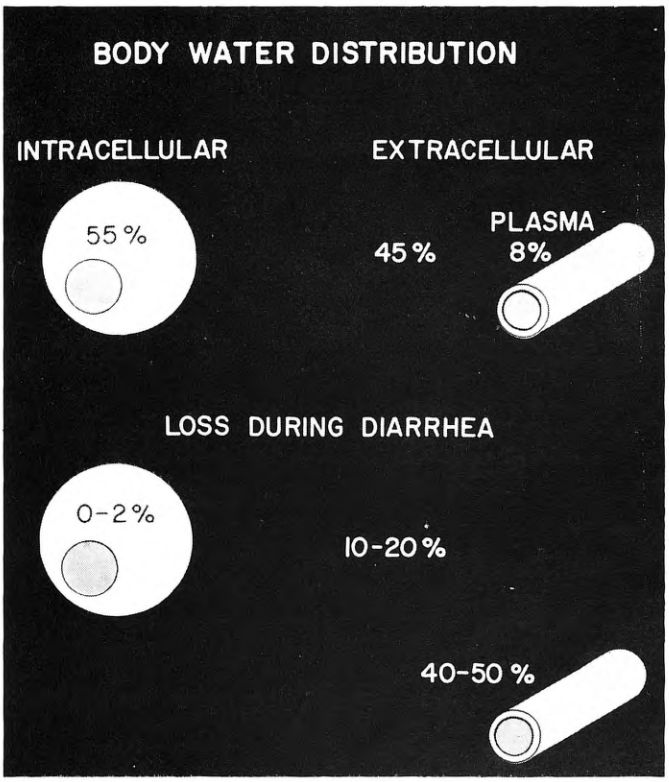

Figure 3: Body water distribution in the normal neonatal calf, and the losses from the three major compartments as a result of acute diarrhea.

acute diarrhea fluids are not lost uniformly from these compartments. This lack of water equilibration is markedly detrimental to the calf. In spite of the fact that most of the body fluids are intracellular, very little water is lost from the intracellular space. The consequences of this will be discussed in the following paper. The interstitial spaces lose significant amounts of water but the most marked change is in the vascular pool. There is a 40-50% decrease in plasma volume (13). This drastic reduction in circulating blood volume can lead to hypovolemic shock which in conjunction with the developing intracellular and extracellular acidosis inhibits normal cellular activity. The loss of functional blood volume can rapidly lead to death unless therapy is instituted. The changes noted above are most typical of very acute diarrhea as it is often seen clinically. When the course of the disease becomes more chronic the water loss tends to be equilibrated between the various pools.

To recapitulate, during diarrhea there is an initial insult to the intestinal transport systems causing either or both an increased secretory activity and a decreased absorption. This leads to fluid accumulation and an increase in microbial colonization in the small intestine. The tremendous fluid and electrolyte losses which occur are

coupled with major shifts in water compartmentalization and electrolyte balance and a severe acidosis develops. The fluid loss which occurs is primarily from the vascular pool which leads to hypovolemic shock.

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