Treatment of Neonatal Calf Diarrhea

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Dr. Miller, in his opening remarks this morning, commented on the diagnostic dilemma that he as a pathologist is faced with when it comes to ascertaining the etiology of abortion and other prenatal disease problems. When it comes to talking about therapy of calf diarrhea, as clinicians, we too are faced with a diagnostic dilemma. Generally, we don't know the exact cause of the diarrheal illness in terms of the type of bacterial or viral agent(s) involved. We don't know if bacteremia or septicemia is present or is imminent as far as the young neonate is concerned and thus we don't know whether to include antibiotic therapy within our overall treatment regime. We don't know the pre-diarrheal body weight of the patient by which we could easily ascertain the fluid requirements and therefore we must resort to some other method of assessing body water loss. Likewise, we don't know the pre-diarrheal hematocrit value or total serum protein concentration of the animal and therefore can't rely on simple laboratory aids in order to calculate body water loss. We often don't know the immunoglobulin status of the animal so as to ascertain the need for plasma, serum or whole blood. This then is the "bad news" as Dr. Giles intimated this morning is that, regardless of the cause, the clinical signs produced in the animal are virtually the same.

This morning I am not sure that I can add much to what most of you already know about the therapy of neonatal calf diarrhea. I have chosen for discussion's sake to divide my treatment regime into four parts - fluid electrolyte replacement, antimicrobial therapy, ancillary therapy and management considerations. I will spend most of my time talking about what I consider to be the most important aspect of therapy - fluid and electrolyte replacement. I am sure there will be considerable discussion during the panel part of this program that will bring out comments relative to the other areas I have listed.

One can not argue against the fact that the most important aspect of the treatment of neonatal calf diarrhea involves fluid and electrolyte therapy. Fluid and electrolyte therapy is aimed at correcting, first of all, dehydration (body water loss) which accounts for the sudden and severe weight loss that the young calf experiences when severe diarrhea occurs. Secondly, it corrects electrolyte deficits caused by the loss of sodium, potassium, chloride and bicarbonate ions in the feces. Thirdly, it corrects the acid base upset evidenced by a variable degree of metabolic acidosis. Fecal pH in these animals tends to be quite alkaline because of the loss of alkaline salts (sodium bicarbonate, potassium bicarbonate)

in the stools, which in turn leads to an acidification of the extracellular fluid. considerable research has gone into trying to ascertain which of these three abnormalities, dehydration, electrolyte imbalance, or acid base upset is of most importance in the overall clinical syndrome and mortality. Certainly in terminal cases, both the acidosis and electrolyte imbalance are of prime importance. In addition to the need for fluid and electrolyte therapy to correct the state of dehydration, there is a need to meet the continuing losses that the animal experiences as the diarrhea continues unabated even in the face of rehydration therapy.

There is a need to supply maintenance requirements of water, electrolyte and calories, particularly in cases of neonatal calf diarrhea that continue for more than 48 hours. In such cases the diarrhea may interfere with appetite and/or the animal may not tolerate milk well. In such cases it may be necessary to fast the animal which removes its normal source of energy and protein.

To determine the amount of electrolyte solution required to correct first of all the dehydration but in addition the electrolyte and acid base upsets as well, one has to determine by clinical techniques the percent dehydration which is the body water deficit calculated as a percentage of body weight.

Table 1:	Clinical Assessment of Percent Dehydration		
	< 4%	6-8%	> 10%
Position of eye in orbit	normal	hollow	sunken
Persistence of skin "tent" of upper eyelid	3-4 seconds	6-8 seconds	indefinitely
Persistence of skin "tent" and twist of skin of neck	3-4 seconds normal	6-8 seconds 3-4 seconds	indefinitely indefinitely

Table 1 lists the factors involved in clinical assessment of the percent dehydration. These factors are the position of the eye in the orbit, persistence of a skin "tent" of the upper eyelid and persistence of a skin "tent" and twist of the skin on the lateral surface of the neck. As is indicated, an animal that is approximately 4% dehydrated tends to have its eye normally positioned within the orbit whereas an animal that is 6-8% dehydrated tends to have a more "hollow" eye than is normal for that breed of animal and the animal that is more

than 10% dehydrated (up to 15% dehydrated) tends to have an obviously sunken eye and if one parts the palpebral margins there is actually a space between the eyeball and the bony orbit of the eye. Some clinicians like to refer to minimal, moderate and severe dehydration as corresponding to the numerical classification listed in Table 1. If a skin fold of the upper eyelid is grasped between the thumb and the index finger and pinched or "tented" in an animal that is approximately 4% dehydrated, the skin "tent" or fold will gradually disappear over 3-4 seconds, whereas in the animal that is 6-8% dehydrated, the skin fold will gradually disappear over 6-8 seconds and an animal that is greater than 10% dehydrated, the skin "tent" will persist indefinitely. Again, some clinicians like to count in seconds the persistence of the skin fold and for each second that it persists 1% dehydration is calculated. Finally, a skin "tent" of the lateral surface of the neck is grasped and twisted 90°. In an animal that is approximately 6-8% dehydrated the twist of the skin on the side of the neck will disappear within 3-4 seconds whereas in the animal that is greater than 10% dehydrated, this skin twist will persist indefinitely. The skin "tent" will gradually disappear over 3-4 seconds in the animal that is approximately 4% dehydrated, disappear over 6-8 seconds in the animal that is 6-8% dehydrated and will persist indefinitely in the animal that is greater than 10% dehydrated. It is worthwhile to remember that, generally speaking, in neonatal calf diarrhea the feces are isotonic. That is, water and electrolyte are lost in the same proportion as found in plasma or extracellular fluid. Thus the animal that is severely dehydrated will have a severe deficit of electrolytes as well and will be in a severe state of acid base upset.

To calculate the fluid requirements to correct the dehydration (the amount of fluid necessary to replace the lost body water and bring the animal back to normal state of hydration) multiply body weight times the percent dehydration as determined using the aforementioned clinical assessment techniques. For example, a 100 lb (45 Kg) calf that is considered to be approximately 4% dehydrated requires 4 lbs or 2 American quarts of electrolyte (1.8 Kg or 1.8 Liters) in order to bring it back to a normal state of hydration. On the other hand, a 100 lb calf (45 Kg) that is 10% dehydrated would require 10 lbs of water or approximately 5 American quarts (4.5 Kg or 4.5 Liters).

Certainly, the *ideal* method for rehydration is by the oral route and a typical solution for oral rehydration is a polyionic alkalinizing solution that contains dextrose and amino acids. In such solutions the sodium ion concentration can range anywhere from 40 to 140 mEq/l, potassium ion concentration from 5 to 30 mEq/l, the chloride ion concentration 30 to 100 mEq/l and the bicarbonate ion concentration 25 to 80 mEq/l. Dextrose can range from 0.5 to 5% and amino acids 1-2%. This type of solution, when properly diluted, can be fed every hour for 2-4 treatments in order to correct the state of dehydration that exists in the animal. Dextrose and amino acids are present because, as

has been well documented in both human cholera and enterotoxigenic *E. coli* diarrhea, sodium absorption and hence rehydration by the incorporation of these chemicals in the oral solution. Of course it goes without saying that the key to successful oral fluid therapy is *early treatment*. One must institute oral therapy before the onset of anorexia and weakness, recumbency, shock and hypothermia. The day is long past when the farmer, particularly the rancher, can wait until the calf is so ill that it can be easily caught before instituting fluid therapy. It is absolutely essential that appropriate facilities be available to isolate either the calf or the calf and its dam in order to facilitate early therapy with an electrolyte solution. One wants to have the calf suckle oral electrolyte solution and thus ensure that the esophageal reflex is activated, the esophageal groove closes and directs the electrolyte solution from the esophagus into the abomasum directly and then into the proximal small bowel where it can be rapidly absorbed. Techniques that employ drenching, the use of a stomach tube or an esophageal feeder invariably result in the material being deposited in the reticulum and cranial sac of the rumen and not in the abomasum. This leads to delay or failure in the absorption of this material which, in the case of moderate to severe dehydration may be fatal. It is very important that the calf should be rehydrated over a period of 2-4 hours with the oral electrolyte solution. When we first started to work with electrolyte therapy we tended to administer the solutions over too long a period and never did accomplish rehydration of the animal. The rate of fluid loss in the diarrhea greatly exceeded the rate of fluid replacement.

The second aspect of the regime - the maintenance of the calf - can be accomplished by the continued feeding of half to one quart or half to one liter of electrolyte solution 3-4 times a day once rehydration has been accomplished. Such volumes should be readily absorbed and prevent the calf from dehydrating further. Since these solutions tend to be salty and sweet, they are very palatable particularly when fed at body temperature. It is often beneficial to calculate a supplemental dose of sodium bicarbonate based on the percent dehydration. By measuring acid base parameters in large numbers of dehydrated calves it has been possible to formulate the following thumb rules. Calves that are considered to be approximately 4% dehydrated require 1 mEq of bicarbonate ion per pound of body weight (2 mEq/Kg body weight). Calves that are 6-8% dehydrated require 2 mEq of bicarbonate ion per pound of body weight (4 mEq/Kg of body weight) and calves that are greater than 10% dehydrated require 4 mEq bicarbonate ion per pound of body weight (8 mEq/Kg of body weight). Thus a 100 lb calf that is considered to be 10% dehydrated would require 100 X 4, that is 400 mEq of bicarbonate ion in order to assist correction of the bicarbonate deficit and speed up the correction of the metabolic acidosis. This can be administered either as an isotonic (1.5% solution) I.V. or orally or as a hypertonic (5%) sodium bicarbonate solution for intravenous use only. Some people might comment that

a 100 lb calf that is 10% dehydrated would not suckle such a solution because with such severe dehydration it would be virtually recumbent and in hypovalemic shock. This need not necessarily be so if the rate of dehydration has been relatively slow and the course of the diarrhea relatively prolonged. In cases where it is impossible to get the animal to suckle the oral electrolyte solution or in spite of supplementing the animal with oral electrolyte it is obvious after 1 to 2 hours that correction of the dehydration is not taking place, as evidenced by persistence of the hollow eyed appearance of the calf and the lack of skin elasticity, it may be necessary to revert to intravenous rehydration. This of course will require intravenous catheterization and the administration of a balanced polyionic alkanilizing solution. The available commercial solutions are based on the original McSherry's solution or formula or lactated Ringers or Darrow's solution. Again, it is important that the volume of electrolyte solution required to correct the dehydration be administered over a period of not more than 3-4 hours. Subsequent to rehydration the animal can be given its maintenance fluid requirement by slow intravenous drip or taken off the I.V. fluids and maintained with oral electrolyte solution.

So much for fluid and electrolyte replacement. Let us consider the second aspect of our therapy regime, antimicrobial therapy. Certainly systemic antibiotic therapy should be used to treat or prevent septicemia. In this regard I think that one can identify three specific situations in which systemic antibiotics should be incorporated as part of the treatment regime. Calves with neonatal calf diarrhea that are less than 5 days of age should be treated with broad spectrum antibiotics, ampicillin, trimethoprim sulfa, chloramphenicol, etc., at full therapeutic doses for at least 3 consecutive days because they are so prone to the development of septicemia. Similarly, calves with a questionable history as regards the intake of colostrum, or known to have ingested poor quality colostrum (calf born to a heifer or a cow with mastitis). Finally, the calf that is severely dehydrated and in a state of hypovalemic shock may be unable to display the typical signs of septicemia because of its water, electrolyte and acid base derangements. Such a calf should automatically receive broad spectrum antibiotic therapy along with its fluid therapy. It goes without saying that calves that have evidence of localized infection, for example navel infection, should also be treated with systemic antibiotics in which case it may be necessary to prolong the therapy for up to 5 days.

I think the use of oral antibiotics is much more questionable. First of all, we don't know whether or not the organism that is causing the problem will be sensitive to the antibiotic that we are going to administer or, in fact, if the organism is sensitive to antibiotics at all. Certainly, from the limited amount of studies that we have done at OVC, it would appear that one or two treatments with an appropriate oral antibiotic will eliminate enteropathogenic organisms from the small intestine. Since prolonged antibiotic therapy has devastating effects upon normal flora, and we are just now recognizing the importance of the normal flora in limiting the proliferation of enteropathogens, one should be cautious about prolonged oral antibiotic therapy. The same comment holds in avoiding the use of several different antibiotics orally. Such a practice should be avoided. Certainly, it is only in cases of persistent diarrhea that I will resort to oral antibiotics as a part of my treatment for neonatal calf diarrhea. My choice of antibiotics will depend on current sensitivity patterns as ascertained in the regional diagnostic laboratory.

The third aspect of therapy of neonatal calf diarrhea involves what I have described as ancillary treatment. This includes the use of intestinal protectants or astringents and of course in the past has also included the use of various antiparasympathomimetic drugs. Certainly, kaolin, pectin, salicylates, bentonite, activated charcoal and many other inert compounds have been used in the treatment of neonatal calf diarrhea. It is now recognized that compounds such bismuth, subsalicylate and salicylates are capable of inactivating endotoxin and enterotoxin and therefore may have a real role to play in the therapy of enterotoxigenic *E. coli* diarrhea. Certainly, I have continued to recommend the use of astringents from the standpoint that, although it may have no significant effect on the diarrhea, at least it gives the farmer something to do and may prevent the excessive use of oral antibiotics. I am sure that during the discussion there will be time to consider these types of treatments in more detail. To date, on a very limited number of cases, we have not had a great deal of success using antiprostaglandin type substances.

The final aspect of my treatment regime includes management consideration. Dr. Acres will have much to say about this particular aspect but I think it is important to emphasize that the diarrheic calf should be isolated or the calf and its dam should be isolated in an attempt to limit the contamination of the environment and break the cycle of spread to other neonatal calves. We have gotten away from the separation of calves from their dams because of the problem of the dam disowning the calf if the separation is prolonged beyond 48 hours and the problem of the calf engorging itself on milk when it is reintroduced to the cow subsequent to treatment. This then touches on the second aspect of management, the reduction of milk intake. One method that seems to be helpful in indirectly staving off the calf's appetite is the feeding of maintenance electrolyte solution frequently through the day. though the calf may still nurse, it tends not to nurse such large quantities and therefore tends not to superimpose indigestion on an already compromised gut.

In summary then, treatment of neonatal calf diarrhea involves the early use of oral electrolyte solutions in amounts based on the clinical assessment of the percent of dehydration. In certain cases it may be advantageous to supplement the animal with extra sodium bicarbonate orally or intravenously, again based on the percent dehydration.

Systemic antibiotics are an important part of therapy in calves that are less than 5 days of age and/or in a shock state and/or in a hypogammaglobin anemic state. As a last resort, oral antibiotics should be considered. Oral astringents may have benefit in the therapy of these disease problems. Finally, isolation of the calf or the calf and its dam along with reduction of milk intake for up to 48 hours may be of benefit.