

Common myths in treating calf diarrhea

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Abstract

Diarrhea remains the leading cause of mortality in both beef and dairy calves. Calves with diarrhea frequently develop dehydration, strong ion acidosis, electrolyte abnormalities, and are in a state of negative energy balance. The primary goals of treating calf diarrhea are to 1) correct free water and electrolyte abnormalities; 2) correct acid-base deficits (acidemia); 3) provide nutritional support; and 4) eliminate and/or prevent *Escherichia coli* bacteremia. There are many different ideas and approaches for how to “best” treat calf diarrhea. Some of these are supported by evidence-based medicine and others are not. The primary purpose of this article is to review some of the more common “ideas” associated with treating calf diarrhea that simply cannot be supported by data. We will try to highlight why these concepts are wrong and how to best approach treating the calf with scours.

Key words: dairy, calves, diarrhea, treatment

Résumé

La diarrhée demeure la principale cause de mortalité à la fois chez les veaux de boucherie et chez les veaux laitiers. Les veaux diarrhéiques développent fréquemment les symptômes suivants : déshydratation, grave acidose métabolique, anomalies électrolytiques et bilan énergétique négatif. Les principaux buts du traitement de la diarrhée chez les veaux sont les suivants : 1) corriger les anomalies électrolytiques et de l'eau libre, 2) corriger le déséquilibre acide/base (acidémie), 3) apporter un soutien nutritionnel, et 4) éliminer ou prévenir la bactériémie causée par *Escherichia coli*. Il existe plusieurs écoles de pensée sur la meilleure façon de traiter la diarrhée chez les veaux. Elles ne reposent pas toutes sur la médecine factuelle. Le but de cette présentation est de faire un survol de certaines idées courantes concernant le traitement de la diarrhée chez les veaux et qui ne reposent pas sur des évidences. Nous tenterons de souligner pourquoi ces concepts sont incorrects et comment il serait mieux de traiter les veaux diarrhéiques.

Myth 1: One oral electrolyte is just as good as another

This topic is covered more extensively in another manuscript within this volume (Myth: one oral electrolyte is just as good as another) so won't be covered in detail here. However there are significant differences in the oral electrolytes that are commercially available for use in calves in North

America and some of the products will not resuscitate calves effectively. Current knowledge regarding the use of oral electrolyte solution (OES) to treat diarrhea in calves would say the product must satisfy the following 4 requirements: 1) supply sufficient sodium to normalize the extracellular fluid (ECF) volume; 2) provide agents (glucose, citrate, acetate, propionate, or glycine) that facilitate absorption of sodium and water from the intestine; 3) provide an alkalinizing agent (acetate, propionate, or bicarbonate) to correct the acidosis usually present in calves with diarrhea; and 4) provide energy, as most calves with diarrhea are in a state of negative energy balance. There are several factors to consider when choosing an oral electrolyte solution which are reviewed in the previous chapter or previous review articles.^{34,35}

Myth 2: If milk is withheld from scouring calves for 1-2 days, the diarrhea will resolve faster

There has been controversy about feeding milk to calves with diarrhea since the 1940's.¹⁹ Some experts have recommended a “rest the gut” approach to treating calf diarrhea – suggesting that continued milk feeding will worsen the diarrhea. This concept is based on the principle that milk will supply nutrients in the intestines that the bacteria could use as an energy source. This would lead to further maldigestion of nutrients and increased excretion of fluids (thus more diarrhea). Other arguments for withholding milk in calves with diarrhea include a faster healing of the intestines, less opportunity for overgrowth of the intestines with harmful bacteria, and impaired digestion and utilization of milk and/or milk replacer. Recommendations in the 1940's were to withhold milk for 1 day and then mix milk and water in a 1:1 solution for the next 2 days.³⁰ Additional studies have suggested that calves with diarrhea should be starved until the diarrhea has resolved.^{26,27,30} Despite these ideas, research has shown milk feeding does not prolong or worsen diarrhea, nor does it speed healing of the intestines. In a study by Garthwaite et al, 42 calves with naturally occurring diarrhea were divided into 3 groups.¹⁴ In 1 group milk was withheld and calves were fed only oral electrolytes, followed by a gradual return to milk after 2 days. In the second group there was partial removal of milk as calves were fed only a small amount (2.5% of body weight for 2 days followed by 5% of body weight for 2 days), along with oral electrolytes. In the third group calves were continued on their full allotment of milk (10% of body weight per day) along with electrolytes. There was no difference in the severity or duration of diarrhea between any of the groups during the study. However, the calves with diarrhea that were fed both milk and oral electrolytes gained

more weight than did calves from which milk was withheld for 1 to 2 days. The calves that continued to receive milk actually gained weight during the study period, while calves in the other 2 groups lost weight. Weight loss in calves limited to only oral electrolyte solutions has been reported in other studies as well.^{13,15,17}

Another study using an experimentally-induced model of diarrhea in calves fed either milk (2 liters every 12 hours), an isotonic oral electrolyte solution (85 mM glucose), or a hypertonic oral electrolyte solution (330 mM glucose) over a 48-hour period. Serum glucose concentrations were unchanged over the 48-hour period in the calves fed milk, but steadily declined throughout the study in both groups fed only oral electrolytes.¹¹ Calves fed only electrolytes developed significant increases in β -OH butyrate and non-esterified fatty acid concentrations over the 48-hour period, indicating these calves were in a profound negative energy balance. A more recent study done on a large dairy in Colorado enrolled 360 calves with naturally occurring diarrhea.¹⁵ One group of calves received the oral electrolyte solution Resorb[®] according to label directions (2 feedings of Resorb[®] only twice a day for 2 days and then 1 liter of milk mixed with 1 liter of Resorb thru day 4 or until diarrhea resolved) while the other group received Diaque[®] according to the label (1 packet mixed with half a gallon of milk twice daily for 2 days and continue if diarrhea persists). The calves in the Diaque[®] group where milk feeding was continued gained more weight during the diarrhea period, had higher weaning weights, and a faster resolution of diarrhea. These studies indicate that even hypertonic oral electrolyte products with very high glucose concentrations do not provide significant energy to meet the maintenance and growth requirements of a calf. Therefore the recommendation to temporarily discontinue milk feeding in calves with diarrhea is inappropriate. Calves should be maintained on their full milk diet plus oral electrolytes when possible. If calves are depressed and refuse to suckle, milk can be withheld for 1 feeding (12 hours) and a hypertonic oral electrolyte product substituted. However, milk feeding should always be resumed within 12 hours.

These recommendations are similar to that for treatment of diarrhea in children. Withholding milk from infants with diarrhea is associated with poor growth rates, slow demeanor, and prolonged recovery. The continued feeding of milk to children with diarrhea has been standard recommendation since the 1940's. The following is an excerpt from "The treatment of diarrhoea: a manual for physicians and other senior health workers" published by the World Health Organization:³⁸ "The infants usual diet should be continued during diarrhoea and increased afterwards. Food should never be withheld and the child's usual foods should not be diluted. Breastfeeding should always be continued. The aim is to give as much nutrient rich food as the child will accept. Most children with watery diarrhoea regain their appetite after dehydration is corrected, whereas those with bloody diarrhoea often eat poorly until the illness resolves. These

children should be encouraged to resume normal feeding as soon as possible." Although recommendations persist amongst some veterinarians and calf specialists to withhold milk during the initial phases of diarrhea, there is absolutely no evidence to support this concept.

Myth 3: If I don't feed antibiotics with milk/milk replacer – I have no chance of avoiding diarrhea

Historically many producers (particularly in the dairy and veal industries) have used the feeding of oral antibiotics to prevent diarrhea and hopefully decrease mortality in newborn calves. However, the practice of continually feeding antibiotics to calves is now prohibited in many countries and the efficacy of feeding antibiotics to calves as a method of diarrhea prevention has not been proven effective in recent studies. Almost 60 years ago, a thorough review was published on the efficacy of antibiotics for preventing diarrhea and improving weight gain in dairy calves.²² The author concluded that the addition of chlortetracycline and oxytetracycline to milk replacer in the first 8 weeks of life decreased the severity of diarrhea in calves. The minimum daily doses necessary for efficacy in this study were 0.15 to 0.20 mg/lb, which led to the routine inclusion of these antibiotics in milk replacers throughout the United States. Unfortunately this study did not look at critical factors such as mortality rate in calves or incidence of diarrhea. The primary benefits of oral antibiotics were found to be higher weight gain and decreased severity and duration of diarrhea. As discussed in a previous review article, there were several studies done in the 1960s and 1970s using various antibiotics (including ampicillin, chlortetracycline, furazolidine, neomycin, oxytetracycline, and streptomycin) to prevent diarrhea in calves.⁷ Although results of these studies varied, only 1 study documented a decrease in mortality rate from diarrhea due to prophylactic oral administration of chlortetracycline.⁹ A few studies did find a decrease in the total number of days of diarrhea associated with antibiotics; however other studies (particularly with neomycin) found increased rates of diarrhea in antibiotic-treated calves.^{29,31} Quite a few of these older studies found oral administration of various antibiotics did not change the incidence of diarrhea in calves as compared to untreated controls.

More recent studies have found either oral antibiotics had no effect on decreasing calf diarrhea or in some cases diarrhea rates actually increased in calves fed antibiotics. For example, a study in California fed one group of Holstein heifers monensin in the starter ration as compared to another group that received lasalocid and chlortetracycline (Aureomycin[®]) for the first 12 weeks of life (in addition to non-medicated milk replacer or whole milk). Antibiotic-treated calves had no difference in average daily gain, feed efficiency or the proportion of calves treated for diarrhea.¹⁸ In another study Holstein heifers were fed milk replacer medicated with oxytetracycline and neomycin or an unmedicated milk replacer that contained a probiotic (Enteroguard - no

longer commercially available). Once again, body weight gain, feed efficiency and the incidence and severity of diarrhea were similar between groups.¹¹ In a third study, 358 dairy calves were divided into 4 groups: medicated milk replacer (neomycin and tetracycline for the first 14 days of life) plus the administration of trimethoprim-sulfamethoxazole, spectinomycin, penicillin and bismuth-pectin for treatment of diarrhea (referred to as conventional therapy); medicated milk replacer for the first 14 days of life and bismuth-pectin for diarrhea and other antibiotics only in cases of fever or depressed attitude (targeted therapy); non-medicated milk replacer with antimicrobial treatment for diarrhea (same treatments as conventional therapy group above); and non-medicated milk replacer with targeted therapy.¹ Calves fed a medicated milk replacer had 31% more days with diarrhea as compared to calves fed non-medicated milk replacer.

In a 2007 National Animal Health Monitoring System (NAHMS) survey, about 60% of dairy farms in the United States fed medicated milk replacers to preweaned heifer calves, most commonly a combination of oxytetracycline and neomycin. This figure had decreased to 37% in the 2014 NAHMS survey following new federal regulations in 2010 that restrict the feeding of medicated milk replacers to a period of 7 to 14 days. Continuous feeding of antibiotics in the milk from birth to weaning is no longer permitted. This is meant to transition the use of oral antibiotics in calves from prophylactic to therapeutic. Medicated milk replacers should now be reserved for the treatment of bacterial enteritis (diarrhea) and bacterial pneumonia in dairy calves and not for prophylactic prevention. In August of 2010, the FDA ruled that the combination of neomycin and oxytetracycline can no longer be used in a 2:1 dosage in milk replacer.²⁴ It must be sold in milk replacer as a 1:1 concentration and used at either a low level (0.05 to 0.10 mg/lb body weight) or high level (10 mg/lb body weight for 7 to 14 days). It is important to note that any extra-label use of medicated feed is not permitted by law and neither veterinarians nor their clients may use, or direct the use of, a medicated feed in an extra-label manner, which includes prescribing it for an unapproved species or higher or lower dose, including for use in calves.²⁴ The use of oral or feed antibiotics in calves would also now fall under the new Veterinary Feed Directive laws as well. The prohibition on extra-label use of drugs in feed (including milk) means that it would be illegal for a beef or dairy producer to do anything other than follow label directions for a medicated feed. If a veterinarian prescribes a drug under the extra-label use provisions of AMDUCA (including adding a drug to a milk replacer, which is considered a feed), this also would be illegal. Giving the drugs orally as a bolus or solution, however, would be acceptable.²⁴

Since the late 1990's, the European Union has prohibited the sale of milk replacers and other animal feeds containing antibiotics. All feed and milk replacers for dairy cattle must be sold as non-medicated, and then antibiotics

can be added only for therapeutic use (for example, in calves with diarrhea). Australia and New Zealand also have strict laws regarding importation of any animal feed and these products are generally non-medicated as well. Overall, the conventional practice of adding antibiotics to milk or milk replacers for prophylactic use is being discouraged worldwide. The majority of modern studies fail to find any benefit to use antibiotics as a prevention for diarrhea and their use in this manner should be discouraged. Therefore there is no scientific evidence to justify the routine inclusion of antibiotics into the milk or milk replacer of calves.

Myth 4: There is no role for antimicrobial therapy in calves with diarrhea.

The use of antibiotics as an ancillary treatment for calves with diarrhea is a controversial topic with strong opinions on both sides. Several articles have been published indicating that antibiotics are contraindicated in calves with diarrhea or that they serve no beneficial purpose. Statements such as "there is no role per se for antibiotics (oral or systemic) in the treatment of calf diarrhea"¹⁶ or "antibiotics are not an appropriate treatment choice for calf diarrhea and should be reserved for pneumonia"¹⁰ are in the recent veterinary literature. One train of thought says that calf diarrhea around the world is primarily caused by rotavirus and *Cryptosporidium*, neither of which would be responsive to antimicrobial therapy. Therefore unless the veterinarian were to specifically isolate a salmonella or pathogenic *E. coli* from a calf with diarrhea, then treating the calf with antibiotics would serve no purpose. In contrast, other studies have indicated that antibiotics are effective in reducing mortality rate and speeding recovery in calves with diarrhea.^{5,6} To begin the discussion it is important to establish a reason to use antibiotics in calves with diarrhea (other than trying to eliminate the primary pathogen). The 2 primary treatment goals of an antibiotic in calves with diarrhea would be 1) to prevent bacteremia and 2) decrease the number of coliform bacteria in the small intestine.

Several studies have reported a significant number of calves with diarrhea subsequently develop bacteremia. An initial study in the early 1960's reported that colostrum-deprived calves with diarrhea were frequently bacteremic (14/17 calves or 82%).³⁵ In contrast, none of the diarrheic calves in this study that had received colostrum were bacteremic (0/26 or 0%). A study conducted on a large calf-rearing facility in California examined 169 dairy calves with severe diarrhea.¹² 129 of the 169 calves (76%) had failure of passive transfer and 47 of the 169 (28%) calves were bacteremic (predominantly *E. coli*). Another study done in Prince Edward Island, Canada looked at the prevalence of bacteremia in 252 calves with diarrhea;²³ 78 of the 252 (31%) calves in this study were bacteremic (predominantly *E. coli*). As noted previously, the percentage of calves with bacteremia was significantly higher in the failure of passive transfer group (47/103 or 46%) as compared to calves with

adequate passive transfer (21/116 or 18%). Taken together, these studies indicate that we can assume 1/3 of calves with severe diarrhea are bacteremic and the percentage is likely significantly higher in calves with failure of passive transfer. Although some have argued that antibiotic use in calves with diarrhea is inappropriate and leads to the emergence of resistant bacteria, a case can be made that the use of antibiotics to prevent and/or treat bacteremia in calves with diarrhea and systemic signs of disease is warranted. Withholding effective treatment (antibiotics) for a life-threatening disease (such as bacteremia in calves with diarrhea) should not be condoned on animal welfare grounds.

Another potential reason for antibiotic therapy in calves with diarrhea is coliform overgrowth of the small intestine. Research conducted in the 1920's documented increased numbers of *E. coli* bacteria in the abomasum, duodenum, and jejunum of calves with diarrhea.^{4,36} More recent studies have consistently found increased numbers of intestinal *E. coli* in calves with naturally acquired diarrhea regardless of the age of the calf or the cause of the diarrhea.^{20,40} Specifically, the numbers of *E. coli* bacteria increase from 5 to 10,000-fold in the duodenum, jejunum, and ileum of calves with scours, even when rotavirus or coronavirus is identified as the cause of diarrhea.^{5,32} This small intestinal overgrowth of the intestines with coliform bacteria can persist after the pathogen causing the diarrhea is gone.⁴⁰ The increased numbers of coliform bacteria in the small intestine of calves with diarrhea is associated with altered small intestinal function, morphologic damage, and increased susceptibility to bacteremia.²⁸ Therefore there is some logic to the use of antimicrobials in scouring calves to decrease the number of intestinal coliform bacteria. This could potentially prevent the development of bacteremia, decrease calf mortality, and decrease damage to the small intestine facilitating digestion and absorption and increasing growth rate.

Efficacy of Using Antibiotics in Calves with Diarrhea

An extensive review published in 2004 examined the question of whether or not antibiotics were effective in diarrheic calves.⁵ It went back and reviewed articles published since 1950 and included studies with both orally and parenterally administered antibiotics in either naturally acquired or experimentally-induced diarrhea. The author examined the effects of antibiotics on 4 critical measures of antimicrobial success in decreasing order of importance: 1) mortality rate, 2) growth rate in survivors, 3) severity of diarrhea in survivors, and 4) duration of diarrhea in survivors. The review looked at over 20 different published studies involving a variety of antimicrobials, several of which would be illegal to use in the United States (ie. chloramphenicol, furazolidone, or marbofloxacin). The results indicated that specific antibiotics were effective in reducing mortality and increasing growth rate when administered to calves with diarrhea. Several studies provided evidence that even calves with

simple diarrhea (without systemic signs of disease) seemed to recover faster with antibiotics as opposed to calves that did not receive antibiotics.

Some veterinarians feel that oral or parenteral administration of antibiotics to calves with diarrhea is contraindicated. The arguments most commonly used to support this approach include: 1) oral antibiotics will alter intestinal flora and will thereby induce diarrhea or exacerbate existing diarrhea; 2) antibiotics will harm "good" intestinal bacteria more than "bad" bacteria; 3) antimicrobial use in calves with diarrhea is not effective; and 4) the use of antibiotics will provide a selection pressure on the enteric bacterial population, likely leading to increased antimicrobial resistance. There is solid evidence to indicate the use of antimicrobial drugs can decrease mortality in calves and there is no evidence to support the argument that antimicrobials "harm good bacteria more than the bad." However, the emergence of resistance bacteria is certainly serious and is something the veterinarian must take into account before treating calves with diarrhea.

Which Antibiotics Should be Used in Calves with Diarrhea

Table 1 contains a list of antimicrobials currently approved for the treatment or prevention of diarrhea in the United States. Currently oxytetracycline administered parenterally and chlortetracycline, neomycin, oxytetracycline, sulfamethazine, and tetracycline administered orally are the only antimicrobials labeled in the United States for the treatment of calf diarrhea. Of these, none have been shown to be consistently efficacious in peer-reviewed studies. As discussed above, when treating calves with diarrhea the 2 primary goals of therapy are to 1) decrease the number of *E. coli* bacteria in the small intestine and 2) treat potential *E. coli* bacteremia. With these goals in mind, the target of antimicrobial therapy in calves with diarrhea should be coliform bacteria both in the blood and small intestine.

Since none of the approved drugs for treating diarrhea in the United States are likely to be effective, extra-label use is likely justified. Some efficacy has been described for oral amoxicillin in the treatment of calves with experimentally induced diarrhea,^{3,25} but was not effective in the treatment of naturally acquired diarrhea in beef calves.²⁶ Amoxicillin trihydrate (4.5 mg/lb or 10 mg/kg PO q12h) or amoxicillin-trihydrate-clavulanate (5.7 mg/lb or 12.5 mg combined drug/kg PO q12h) for at least 3 days is 1 antimicrobial approach that likely has some efficacy for calves with diarrhea. Amoxicillin is partially absorbed from the calf small intestine, with absorption being similar in both milk-fed and fasted calves.⁴¹ High amoxicillin concentrations are found in bile and intestinal contents after oral administration, with lower concentrations in serum.²⁵ Oral ampicillin could also be used and its efficacy in 1 study was shown to be equivalent to amoxicillin.²¹ Although very popular in the United States, oral sulfonamides cannot be recommended for treating calves

Table 1. Antibiotics approved in the United States for control and/or treatment of calf diarrhea. The list of trade names is not necessarily complete.

Antibiotic	Trade Name	Manufacturer	Label Claim	Dose
Chlortetracycline	Aureomycin® Soluble Powder Concentrate	Zoetis	Control and treatment of scours caused by <i>E. coli</i> or <i>Salmonella</i> spp	10 mg/lb of body weight for 3 to 5 days orally
Chlortetracycline	Aureomycin® 90 Granular or Meal OR CLTC® 100 MR	Zoetis OR Phibro	Treatment of scours caused by <i>E. coli</i>	10 mg/lb of body weight mixed or top dressed on feed daily for up to 5 days
Chlortetracycline	ChlorMax® 50	Zoetis	Treatment of scours caused by <i>E. coli</i>	10 mg/lb of body weight in milk replacer or starter feeds for up to 5 days
Neomycin	Neomed® 325 Soluble Powder	Bimeda	Control and treatment of scours caused by <i>E. coli</i>	10 mg/lb of body weight mixed in drinking water – maximum of 14 days
Neomycin	Neomycin Oral Solution	AgriLabs	Control and treatment of scours caused by <i>E. coli</i>	10 mg/lb of body weight given orally divided into at least 2 doses per day – maximum of 14 days
Neomycin-oxytetracycline	Neo-Terramycin® 50/50 or Neo-Terramycin® 100/100	Phibro	Treatment of <i>E. coli</i> diarrhea	10 mg/lb of body weight fed continuously for a maximum of 14 days
Neomycin-oxytetracycline	NT Concentrate	Land O Lakes	Treatment and control of <i>E. coli</i> diarrhea	Mix in milk replacer to deliver 10 mg/lb of body weight fed continuously for a maximum of 14 days
Oxytetracycline	300 Pro LA	Norbrook	Treatment of <i>E. coli</i> diarrhea	3 to 5 mg/lb of body weight daily IM or SC for up to 4 days
Oxytetracycline	Agrimycin® 200 or Bio-Mycin® 200 or Duramycin 72-200	AgriLabs OR Boehringer Ingelheim OR Durvet	Treatment of <i>E. coli</i> diarrhea	3 to 5 mg/lb of body weight daily IM or SC for up to 4 days
Oxytetracycline	Calf scours bolus	Durvet	Control and treatment of scours caused by <i>E. coli</i> or <i>Salmonella typhimurium</i>	250 mg per 100 lbs of body weight orally every 12 hours for up to 4 days (control) or 500 mg every 12 hours (treatment)
Oxytetracycline	Terramycin® Scours Tablet OR Oxy 500 Calf Bolus	Zoetis OR Boehringer Ingelheim	Control and treatment of scours caused by <i>E. coli</i> or <i>Salmonella typhimurium</i>	2.5 mg/lb of body weight orally every 12 hours for up to 4 days (control) or 5 mg/lb every 12 hours (treatment)
Oxytetracycline	Terramycin® 50, 100, 200 or 200 Granular OR Terramycin® 100MR	Phibro	Treatment of <i>E. coli</i> diarrhea	10 mg/lb of body weight fed continuously for 7 to 14 days
Sulfamethazine	SMZ-MED 454 OR Sulmet® Powder	Bimeda OR Huvepharma, Inc.	Treatment of <i>E. coli</i> diarrhea	108 mg/lb of body weight on day 1 followed by 54 mg/lb on days 2, 3, and 4 mixed in water
Sulfamethazine	Sustain III® Boluses	Bimeda OR Durvet OR VetOne	Treatment of <i>E. coli</i> scours	160 mg/lb of body weight given orally – given once every 3 days for a maximum of 2 treatments
Tetracycline	Tetramed® 324 HCA OR Tetra Bac 324® OR TC Vet 324® OR Tetracycline SP 324 Powder	Bimeda OR AgriLabs OR OR VetOne OR Aspen	Control and treatment of <i>E. coli</i> diarrhea	Dissolve in drinking water to provide daily dose of 10 mg/lb of body weight for up to 3-5 days

with diarrhea due to lack of efficacy studies. Most antimicrobial susceptibility studies done in the last 30 years indicate sulfamethazine (and other sulfonamide drugs) would likely have very poor sensitivity against coliform bacteria in the blood or small intestine.

The most logical antimicrobial for parenteral treatment of calf diarrhea in the United States is ceftiofur (1 mg/lb or 2.2 mg/kg IM q12h) for at least 3 days. Ceftiofur is a broad-spectrum antibiotic that is resistant to β -lactamase. The labeled dose maintains plasma concentrations of ceft-

iofur above the MIC₉₀ value for *E. coli* (0.25 µg/mL) in young calves. Furthermore, 30% of the active metabolite (desfu-roylceftiofur) is excreted into the intestinal tract of cattle, providing activity in both the blood and the small intestine. Parenteral ampicillin (4.5 mg/lb or 10 mg/kg IM, q12h) is another antibiotic that would be likely to have efficacy in calves with diarrhea. In Europe, parenteral enrofloxacin is labeled for the treatment of calf diarrhea, and several studies have documented efficacy with using fluoroquinolone antibiotics in calves with diarrhea.^{37,39} However, it must be emphasized that the extra-label use of fluoroquinolone antibiotics in the United States is illegal and obviously not recommended. Historically, gentamicin was also considered an appropriate treatment for use in calves with diarrhea. However parenteral administration of aminoglycosides cannot be recommended in calves with diarrhea due to the lack of published efficacy studies, prolonged slaughter withdrawal times (18 months), potential for nephrotoxicity in dehydrated calves, and availability of other drugs likely to be equally successful (ceftiofur, amoxicillin, ampicillin).

The issue of whether or not to use antibiotics in a calf with simple diarrhea (without systemic signs of disease) is a little more controversial. Although there have been studies to show these calves gain more weight and recover faster than calves not given antibiotics, there are other studies that indicate no benefit to using antibiotics in these cases.^{2,10} The clinician must weigh any potential benefit of antimicrobial therapy against the possibility of increasing the population of resistant bacteria on the farm. A fairly recent study demonstrated that individual treatment of sick calves with antibiotics increased the level of resistance to *E. coli* isolates; however, the change in antimicrobial susceptibility was only transient.²

Certainly the overuse of antibiotics is a concern and the overall philosophy in veterinary medicine is to use antibiotics conservatively to preserve the efficacy of these drugs in both animals and humans. Based on the need to minimize the use of antibiotics and because of the lack of any recent demonstrated recent efficacy, the feeding of antimicrobials to calves as a method of diarrhea prevention is not recommended. However, calves with diarrhea and systemic signs of illness should receive antibiotics targeted towards coliform bacteria in the blood (due to likelihood of bacteremia) and the small intestine (due to bacterial overgrowth). A clinical sepsis scoring system to predict bacteremia based on physical examination does not appear to be sufficiently accurate to guide antimicrobial decision making, and therefore the clinician should assume calves are bacteremic when they exhibit inappetence, dehydration, lethargy or fever. In calves with diarrhea and no systemic signs of illness (normal appetite for milk, no fever), evidence suggests that the clinician continue to monitor the health of the calf and not administer antibiotics unless the calf's condition deteriorates.

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