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Review of Common Bacterial Cause and Management of Neonatal Calf Diarrhea in Cattle

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Abstract: Neonatal calf diarrhea or calf scours is a common disease that affected the newborn calf and it occurs when the capability of the intestine to absorb fluid is impaired. Calf scours is not a single disease entity, it is a clinical syndrome associated with several diseases characterized by diarrhea. The scouring calf loses fluids, rapidly dehydrates and suffers from electrolyte loss. Many of the bacterial agents responsible for scours are commonly isolated in the environment and carrier adult animals within the herd. The primary bacterial agents responsible were *E. coli*, *Salmonella* and *Clostridium* species. Some *E. coli* species may cause profuse watery diarrhea while others may be linked to bloody scours of variable severity. The major concern with calf diarrhea is dehydration resulting from the cause of diarrhea. Oral rehydration is important in the prevention of dehydration. Strict biosecurity, biocontainment, improving management systems and vaccination are important methods to prevent calf diarrhea in dairy cattle.

Key words: Calf Scours · Clostridia · *E. coli* · Prevention · Salmonella

INTRODUCTION

The health and management of replacement animals are important components of total herd profitability. The productivity of the herd can be negatively affected by impaired growth of calves, decreased milk production that experienced chronic illness as calves, the spread of infectious diseases from calves to adult cows, increased veterinary costs and the limited opportunity for genetic selection due to high mortality of replacement animals. Among all animals present on a dairy farm, the highest morbidity and mortality rates occurred in calves before weaning [1].

Neonatal calf diarrhea (NCD) also known as calf scours is a common disease that affected newborn calf. Diarrhea or scouring occurs when the capability of the intestine to absorb fluid is impaired. Interference with this absorptive function of the intestine may occur in two ways. Damage to the cells lining the intestine may result from cell destruction by certain infectious agents, resulting in loss of the digestive and absorptive capability of the intestine as well as inflammation [2].

Calf scours' (diarrhea) is the most common symptom of illness in young calves and is usually a problem in the first month of life. The scour can be white, yellow, grey or blood-stained and is often foul-smelling. Although more common in hand-reared calves, it can also occur in calves that are being suckled by their mothers [3]. Whatever the cause of the scour, the lining of the bowel is damaged, resulting in the loss of large amounts of body fluid into the gut. As a result, the calf quickly dehydrates, electrolytes become unbalanced, energy reserves are depleted and the calf may develop shock and die. Diarrhea is one of the most likely reasons young beef calves become sick or die [4].

Besides its detriment to calf health and well-being, calf scours is costly to cattle producers due to poor calf performance, death and the expense of medications and labor to treat sick calves [5]. Calf scours is a complex disease, with many interrelated causes [6]. Calf scours is not a single disease entity; it is a clinical syndrome associated with several diseases characterized by diarrhea. Regardless of the cause, absorption of fluids from the intestine occurs; that is, the scouring calf loses

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fluids, rapidly dehydrates and suffers from electrolyte loss and acidosis [7].

Several infectious agents have been recovered from calves with diarrhea [8]. Common agents of calf diarrhea include bacteria such as *Escherichia coli* and *Salmonella*, viruses such as *rotavirus* and *corona*virus and protozoa such as *cryptosporidia*. Knowing the name of an agent recovered from a calf with scours may explain the immediate cause of the calf's illness or death, but that knowledge rarely explains the outbreak or provides a solution for treatment, control, or prevention. Further, it is typical that multiple agents can be recovered from herds experiencing outbreaks of calf diarrhea; suggesting that even during outbreaks more than one agent may be involved. The adult cow herd commonly serves as the source of pathogens from one year to the next [9].

Many of the bacterial agents responsible for scours are commonly isolated in the environment and carrier adult animals within the herd. The primary bacterial agents responsible include *E. coli*, *Salmonella* and *Clostridium* species. Some *E. coli* species may cause profuse watery diarrhea while others may be linked to bloody scours of variable severity [10]. Agent, host and environmental factors collectively explain scours and these factors interact dynamically over time. Cattle producers and their veterinarians should understand the relationships between these factors within the production system to control the disease or prevent its occurrence [11]. Hence the objective of this paper was to review major bacterial causes, control and preventive principles of calf scour in cattle.

Common Bacterial Cause of Calf Scours

Escherichia coli: *Escherichia coli* is a very common and serious bacterial cause of neonatal calf diarrhea (NCD). Neonatal calf diarrhea caused by *E. coli* is called colibacillosis. There are many strains of disease-causing (enteropathogenic) and non-disease causing (non-pathogenic) *E.coli*. As a result, it is essential that the disease-producing types be recovered from the diarrheic animal and properly identified to a valid diagnosis to be established [2].

The virulence attributes of enterotoxigenic *E. coli* include the adhesion in their pili or fimbriae that allow them to adhere to intestinal villous epithelial cells and prevent peristaltic elimination by the gut and the production of heat-stable and heat-labile enterotoxins. The major virulence attribute enterotoxigenic strains of *E. col* in calves are the K99+ adhesion antigen and the heat-stable enterotoxins [12].

The occurrence of enterotoxigenic *E.coli* in diarrheic calves varies widely with geographically, between herds depending on the age of animals. The prevalence can be as high as 50-60% in diarrheic calves under 3 days of age and 5-10% in diarrheic calves 8 days of age. Thus, enterotoxigenic colibacillosis is a major cause of diarrhea in calves less than 3 days of age and is not associated with an outbreak of diarrhea in calves older than 3 days [12]. Severe outbreaks of *E. coli* may affect calves as young as 16 to 24 hours. The younger calves have a greater chance of death from progressive severe dehydration [13].

The organism spread within a herd through the feces infected animals all inanimate objects that can be contaminated by feces, including bedding, pails, boots, tools, clothing, feed and water supplies. Most newborn calves have a chance to pick up *E. coli* scours infections from the environment, particularly when sanitation is marginal. Calves acquire the infection from contaminated bedding and calf pails, dirty calf pens, nearby diarrheic calves, crowded calving grounds and from the skin of perineum and udder of the mother [12].

The majority of *E. coli* strains able to cause diarrhea first colonize (or adhere) to the calves' gut. They do so using very fine, fuzz like protrusions known as pili or fimbriae. These pili arc designated as the K99 antigen. *E. coli* strains that possess the K99 antigen are called enterotoxigenic *E. coli* (ETEC). Enterotoxigenic means the ability to produce toxins in the intestines [14]. Enterotoxigenic strains of *E.coli* colonize and proliferate in the upper small intestine and produce an enterotoxin, which causes an increase in the net secretion of fluid and electrolytes from the systemic circulation. The adhesion of *E. coli* to the intestinal epithelial cells is mediated by bacterial pili [12]. Enterotoxigenic *Escherichia coli* (ETEC) strains can produce fatal diarrhea in neonatal calves. These organisms possess at least two known virulence factors: production of enterotoxins, which produce diarrhea by a mechanism of villous hypersecretion [15] and surface antigens, known as pili or fimbrial adhesions, which facilitate colonization of the small intestine. The K99 pilus antigen is one of the major adherence factors found on ETEC of neonatal calves [16].

In diagnosing *E. coli* as a cause of diarrhea, demonstration of fimbrial antigens (K99 in case of calves) or the enterotoxins is necessary. Fimbrial antigens can be detected by immunological tests like latex agglutination test or ELISA either directly from fecal samples or from the culture of *E. coli* in special media that support the expression of fimbrial antigens. Fluorescent antibody

technique using conjugates prepared against colonizing antigens can be used on smears made from scraping from the ileum of the fresh carcass. The most sensitive of the methods being developed for heat-labile and heat-stable toxins is ELISA, which employs monoclonal antibodies [17].

***Clostridium*:** *Clostridium perfringens* are gram-positive, spore-forming, anaerobic bacteria that are very commonly found in many environments, including soil, water, poorly preserved feeds, contaminated or improperly thawed colostrum or milk, calf housing environments and the normal bovine intestinal tract. In small amounts, these bacteria are generally harmless in the intestine, but under the right conditions they may grow and proliferate, resulting in enterotoxaemia, a condition in which specific toxins produced by the bacteria in the small intestine result in both local damage and systemic (whole-body) effects [18].

Clostridium perfringens type C causes necrotic enteritis in newborn calves. Affected calves may die before they develop diarrhea. Calves are suddenly depressed, weak may be distended, or show abdominal pain. If diarrhea develops, it may have blood and tissue streaks. *Clostridia* organisms are, for the most part, normal flora of cattle and only become problematic with dietary stress, injury and changes in management, parasitism, or other unusual circumstances that set up a favorable growth environment and result in the production of potent toxins [19].

Clostridium infections usually occur in young animals particularly in calves less than two weeks of age, although it has been reported in calves up to two months of age [20]. Type C is one of the more commonly encountered types of *C. perfringens*. It is especially virulent in calves less than 10 days old (and often less than five days old) [18]. The epsilon toxin could probably be transmitted in contaminated food, water, or by aerosol. Pathogenic clostridia are commonly present in soil rich humus and may multiply in the soil in warm weather following heavy rain. It also found in the intestinal contents of normal animals and cause diseases [21].

The organism is ingested from the soil and fecal contamination on the surface of the dam's udder. It proliferates and attaches to the surface of the epithelial cells of the intestinal villus, but toxin production and mucosal damage may precede attachment [18]. Because of the widespread nature of the organism, calves are readily exposed to *C. perfringens* in their environment and commonly ingest the bacteria in various quantities, after which it enters the stomach and intestines. Sometimes bacteria are ingested in sufficient quantities to cause disease, but often time's small quantities are ingested, followed by rapid proliferation in the Intestine [20].

Samples for culture (intestinal contents, blood clots, liver and feces) should be placed in clean zip-lock bags and refrigerated or frozen until they can be shipped. Note well: *C. perfringens* is a common occurrence in the intestine of normal animals, there is a tendency for rapid bowel overgrowth and systemic invasion of tissues after death so rapid harvest and appropriate preservation of tissues before the submission is essential. Combined findings of the organism, toxin and compatible history and lesions are necessary to confirm a diagnosis [21].

Salmonella: Disease in calves due to *Salmonella* infection is a common problem in Arizona, particularly in confined animals such as dairy calves. Salmonellosis is most severe in calves under a month of age [2]. *Salmonella* serotype *Typhimurium* causes localize infection in calves, with the most severe pathological lesions being restricted to the intestinal mucosa and mesenteric lymph node. Animals develop fibrin purulent necrotizing enteritis characterized by severe diffuse infiltrate composed predominantly neutrophils [22].

The important persistence of *Salmonella* in the environment appears to be an important factor in the epidemiology of calf salmonellosis and indicate the inadequacy of many cleaning and disinfection routes [23]. The source of *Salmonella* infection in a herd can be from mother cattle, birds, cats, rodents, water supply, or human carriers. Saliva, nasal secretions, colostrum and milk can also be the source of organisms shed from sick animals and oral transmission from these sources is another way to spread disease on a dairy [24]. Direct animal to animal transmission is thought to occur via a fecal-oral route [25]. Indirect transmission of *Salmonella* can also occur by the use of contaminated feed and water supplies, pasture contaminated by slurry or sewage and wildlife vectors such as small mammals and birds [12].

The pathogenesis of *Salmonella Dublin* can be seen as a series of more or less overlapping steps: uptake of bacteria and passage to the small intestines, colonization of the intestinal lumen, invasion of the intestinal epithelial cells, uptake by macrophages in the underlying lymphoid tissues, dissemination via the lymph fluid to other organs rich in reticuloendothelial tissues (e.g. lymph nodes, liver, spleen, bone marrow) and the circulating blood [23].

Table 1: Guide to estimate the degree of dehydration in a calf clinical sign

Symptoms	Percentage
Diarrhea, but no other sign	5 %
Eyes slightly sunken, skin losing elasticity, but calf still suckling.	7 %
Eyes sunken, skin slow to flatten if pinched, gums sticky, calf depressed.	9 %
Eyes very sunken, skin 'tents' (won't flatten if pinched); calf can't stand and is severely depressed.	12 %

Source [3]

Table 2: The fluid requirement for treatment of diarrhea

Calf Health	Dehydrated (%)	Dairy Milk	Oral Fluids
Healthy calf	0%	4.4 kg	0 kg per day
Mild diarrhea	2%	4.4	1.1 kg per day
Mild diarrhea	4%	4.4	2.2 kg per day
Depressed	6%	4.4	3.3 kg per day
Very ill	8%	4.4	4.4 kg per day
Recumbent	>10%	4.4	Need intravenous fluids than oral electrolyte

Source [30]

Cultural isolation of the organism from the feces sample is the usual method of diagnosing *Salmonella* from diarrheic calves. This involves the inoculation of feces to selective enrichment broths. After overnight incubation in selective enrichment, it will be transferred to selective plating media. Colonies showing characteristics of *Salmonella* will then be tested biochemically and serotyped [17]. The application of ELISA can provide information about the infection status of the animal and the flock. Moreover, the repeated testing of animals differentiates those recently infected calves (increasing antibody titer) and those convalescent ones (decreasing titers) from *Salmonella* carriers which would have relatively constant titers [26].

Histopathological evaluation of calf intestinal tissue collected between 18 and 48 hours after oral infection with *Salmonella* serotype *Typhimurium* reveals necrosis of the uppermost mucosa with loss of the intestinal epithelium and discernible villi or crypt structure. A comprehensive evaluation of the hematology and blood chemistry profile of orally infected. Calves have been performed to test the prediction that *Salmonella* serotype *Typhimurium* induced diarrhea results in the non-specific effusion of serum protein [27].

Treatment and Prevention of Calf Scours

Symptom Management: The treatment of scours in calves should aim to replace lost body fluids, correct the electrolyte imbalance and supply energy [3] as described in Table 1. The major concern with diarrhea is dehydration, regardless of the cause of diarrhea. Oral rehydration is an important aspect in the prevention of dehydration [28]. Oral rehydration can be accomplished by the intake of commercially prepared fluids that contain specific quantities of electrolytes and glucose and should be started with the onset of diarrhea [29] as showed in Table 2.

Treatment for scours is very similar regardless of the cause. It should be directed toward correcting dehydration, acidosis and electrolyte loss. Antibiotic treatment can be given simultaneously with the treatment for dehydration. Dehydration can be overcome with simple fluids given by mouth early in the course of the disease. If dehydration is allowed to continue, intravenous fluid treatment calves are important [13].

Calves affected with dehydration and diarrhea due to collibacillosis absorbs electrolyte solution as effective as healthy calves. The absorption of glucose and glycine is accompanied by the absorption of water and sodium. Thus such a solution would have an advantage over an isolated saline solution. Study on the availability of oral carbohydrate neonatal indicate the fruit pectin is equivalent to glucose, corn syrup is that less effective than glucose and Sucrose is to fully unavailable in their effect on plasma glucose concentration [31].

In calves affected with present diarrhea due to chronic disease of the alimentary tract or which cannot or will not eat, total intravenous feeding may be indicated. The high concentration of glucose, protein, hydrolyte and electrolytes is given by continuous slow intravenous infusion over several days. The total daily amounts given are calculated based on daily caloric requirements [32].

Correction of the Underlying Problem: If the cause is found to be a medication, the offending medication should be stopped if possible and another substituted if needed [33]. Antibiotics should be used both orally and by injection whenever treating calves for diarrhea.

In acute salmonellosis outbreaks, antibiotics may cause the release of excess endotoxins; therefore, consideration should be given to using fluid therapy only [34]. Treatment of salmonellosis in animals is often ineffective due to the presence of an antibiotic drug-resistant strain of *Salmonella* and failure to identify the drug susceptibility pattern of involved strain [17].

Biosecurity and Bio-Containment: Biosecurity is the sum of actions taken to prevent introducing a disease agent into a population (pen, herd, region) and bio-containment describes the actions taken to control a pathogen already present in the population [35]. In theory, outbreaks of calf diarrhea could be prevented by eliminating the pathogens, increasing calf resistance, or altering the production system to reduce opportunities for pathogen exposure and transmission. However, the endemic nature of the common pathogens of calf diarrhea makes it unlikely that cattle populations could be made biosecure from these agents. Maternal immunity from colostrum is important to calf susceptibility to scours pathogens [36]. However, the protection decreases with time and managers of extensive beef cattle systems have limited practical opportunities to improve calf ingestion and absorption of colostrum antibodies [37].

Also, vaccines are not available against all pathogens of calf diarrhea, may not provide sufficient cross-protection and pathogens may evade the protection afforded by vaccination by evolving away from vaccine strains for these reasons, a bio-containment approach to control calf diarrhea seems more useful. All in the all-out principle of successive population and depopulation of farrowing quarters and calf barn is an effective method of maintaining a low level of contamination of pressure for the neonate [38].

Good quality colostrum and a guaranteed intake of antibodies are the first line of defense and the key upon which most of the other measures depend. Sanitation is the other means to control and prevent scours. There is only one practical way to get antibodies against these diseases into the newborn calf and that way is through the mouth into the gut where the antibodies are absorbed into the intestine [13].

Managemental Aspects: All facets of management are important. Particular attention should be paid to nutrition, environment, sanitation and care of the newborn calf [13]. Many diseases of newborn calves can be controlled by well-designed health management programs that define the care and housing of the dam during the per parturient period, standard operating procedures for the calving process and the application of proper preventive measures (including sound nutritional programs) for the newborn calf. Efficient replacement programs endeavor to calve. Healthy calves can achieve growth rates that allow them to be breed at 13 to 15 months of age and maximize the potential productivity of the overall dairy herd [39].

The sandhills calving system prevents effective contacts by using clean calving pastures, preventing direct contact between younger calves and older calves and preventing later-born calves from being exposed to an accumulation of pathogens in the environment [40]. There is a linear relationship between the concentration of immunoglobulin in the colostrum and absorption in immunoglobulins by a calf during the period of maximum absorption [41]. The removal of the caw calf pair from the main calving ground to a nursery pasture after the caw calf relationship (neonatal bond) is well established at 2-3 days of age has proved to be successful management practice in beef herds [12].

Good quality colostrum and a guaranteed intake of antibodies are the first line of defense and the key upon which most of the other measures depend. Sanitation is the other means to control and prevent scours [13]. Supporting the normal intestinal flora by the use of additives such as oligosaccharides, oral Antibodies (IgG), bacteria (probiotics) may be helpful. A study indicated that green tea extracts inhibited the growth of pathogenic bacteria in the intestines of calves, including *C. perfringens* [42].

Vaccination: Vaccination strategies should take into consideration the necessity for a booster vaccination approximately 4 weeks after the first vaccination. Dry cow vaccination with good colostrum feeding is the best way to prevent *Clostridia* diseases in calves. Vaccination of 4 to 6-month-old heifers with *Clostridium perfringens* containing bacterin/toxoids can produce a sustained immune response that can be boostered annually or semi-annually [19].

A well-planned and consistent vaccination program is an effective tool to prevent scours if the management aspects are taken care of Kumaresan *et al*. [43]. If *E. coli* has been shown to cause a problem on the farm, a commercial vaccine, BOvac®, is available. The vaccine is given to heifers 6 weeks and 2 weeks before calving and a booster is given to cows 2 weeks before calving. Antibodies against *E. coli* are then boosted in the colostrum and this protects the calves from infection [3].

It was demonstrated that newborn calves challenged with ETEC are protected from fatal diarrhea if they ingest the colostrum of cows previously vaccinated with purified K99 antigen [44]. Several other vaccine trials using a variety of K99-containing preparations, including whole-cell bacterins and crude cellular extracts, also demonstrated that passive antibody against the K99 antigen prevents severe fatal enteric colibacillosis when ingested by newborn calves soon after birth [45].

CONCLUSION

Calf scours (diarrhea) is the most common symptom of illness in young calves and is usually a problem in the first month of life. Common agents of calf diarrhea are bacteria such as *Escherichia coli, Clostridium* and *Salmonella*. Calf diarrhea can be an uncomfortable and on occasion, life-threatening symptom. Calf scours is a preventable and treatable condition. In general, outbreaks of calf diarrhea could be prevented by eliminating the pathogens, increasing calf resistance, or altering the production system to reduce opportunities for pathogen exposure and transmission. It is important to remember that oral rehydration therapy is the mainstay for the treatment of calf scours. The main aim of treating calf scours is to replace lost body fluids, correct the electrolyte imbalance and supply energy.

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