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Review on Common Infectious Diseases of Neonatal Calves

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Abstract

Neonatal calf mortality is one of the important problems of calf rearing in dairy farms worldwide. A successful dairy farm operation requires that a large percentage of cows wean a live healthy calf every year. However, in many developing countries, a large number of calves die during the early neonatal life, this causing heavy economic loss. This is due to several infectious (bacterial, viral, and protozoal) and non-infectious factors (management around birth, colostrum management, calf housing, feeding system, hygiene, and pathogens) play an important role in calf rearing. This paper aims to review major infectious causes of neonatal calf mortality. Numerous studies have been conducted in the past from many parts of the world using both retrospective and prospective data sources to document the major causes of calf mortality. Of the infectious diseases of calves, neonatal diarrhea is a matter of major concern, and multiple etiological agents from viruses (Bovine rotavirus, Bovine coronavirus, Bovine viral diarrhea virus) from bacteria (*Salmonella* spp, *Escherichia-coli*, and *Clostridium perfringens*) from protozoal (*Cryptosporidium-parvum*) have been identified as major causes of neonatal calf mortality. Among the infectious agents, rotavirus and E. coli are mainly involved in the causation of neonatal calf diarrhea which leads to high mortality and morbidity in young calves. *E. coli* mainly plays its role up to the second week of life whereas, rotavirus up to the third week. Generally, early calf mortality leading to economic losses due to the cost of treatment, prophylaxis, increased susceptibility to other infections, reduced growth rates, and death of calves.

**Keywords:** Calf Mortality; Infectious Diseases; Diarrhea

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Introduction

Dairying is becoming one of the most important parts of the livestock sector where calves are a future herd of a dairy farm in many developing countries to achieve better living standards. A successful dairy farm operation requires that a

large percentage of cows wean a live healthy calf every year. The survival of calves and their rapid growth is the most important factor responsible to enhance the sustainability and propagation of the dairy herd [1]. Moreover, in dairy enterprises survivability of the calf is an important trait both for breeding and economic issue. However, in many developing countries,

a large number of calves die during the early neonatal life, this causing heavy economic loss. Diarrhea is one of the most important causes of morbidity and mortality, leading to economic losses due to the cost of treatment, prophylaxis, increased susceptibility to other infections, reduced growth rates, and cause death of calves [2]. The success of any commercial dairy farm mainly depends on the survival rate of calf crops produced by the dairy farms, but most of the dairy farms are confronted with acute problems of neonatal calf mortality [3].

Neonatal mortality (NM) is one of the most serious diseases worldwide among new-born calves (<1-month-old). It is roughly estimated that calf mortality of 20% can reduce net profit to 38% [4]. Numerous studies have been conducted in the past from many parts of the world using both retrospective and prospective data sources to document the major causes of calf mortality. A study reported that the rate of neonatal calf mortality between 1.5% and 50% in Sululta Ethiopia [5], 15.2% in Uruguay [6], between 5.4% and 18.9% in India [7], between 10% and 70% in Wolaita [8], between 7% and 29% in northern Mexico [9,10]. Reported the overall mortality rate was 31.22%, with the maximum percentage (15.12%) of calves died within one month of age after birth in Jersey x Sahiwal crosses. However, neonatal calf mortality varies from 8.7 to 64 % throughout the world. Neonatal calf mortality in the first month of age is accounted to be 80-85% of calf mortality and is particularly high in the third week of life [11]. A high rate of calf mortality indicates an irrefutable and irrevocable economic loss to the dairy farm due to loss of the present value of the calf and loss of genetic potential for herd improvement, loss of females for further replacement, and increase treatment cost [12].

Several factors influence the health and vigor of the calves in the neonatal period. Major calf diseases that cause mortality are the results of either alone or complex interaction of the infectious and non-infectious. The important infectious causes are due to viral agents (Rotavirus type A, bovine coronavirus, and

bovine viral diarrhea), bacterial agents (*Salmonella* spp., *Escherichia-coli* (*E.coli*) K99+, and *Clostridium perfringens*, and protozoan (*Cryptosporidium parvum* and *coccidiosis*). Some of the non-infectious causes are due to management problems, inadequate nutrition, exposure to severe environmental conditions, insufficient attention to the newborn calf, and failure of passive transfer of immunity [13,14]. Economic losses due to calf mortality are the first and foremost cores of dairy farm management. For this reason, the identification of factors that are responsible for the death of calves is an important prerequisite for reducing excessive mortality. Therefore, with this background information, this seminar paper aims to review the major infectious diseases of neonatal calves.

### Infectious Causes of calf mortality

Viruses, bacteria, and protozoans are known to cause infectious diarrhea, this may be associated with a single infection or mixed infections and increased damage. Diarrhea in neonatal calves is one of the most challenging clinical syndromes encountered by practicing large animal veterinarian's worldwide [15]. High mortality of neonatal calf is due to gastroenteritis, pneumonia, and septicemia. Among these, up to 60% of total calf mortality is attributed to gastroenteric conditions. Various infectious agents have been implicated in calf diarrhea. Bovine practitioners and cattle producers are aware of many enteric pathogens because these primary agents have been known to be involved in calf diarrhea for several decades and still greatly influence current cow-calf operations. Among the infectious diseases of calves, neonatal diarrhea is a matter of major concern, and multiple etiological agents like bovine rotavirus (BoRV), bovine coronavirus (BCoV), Bovine viral diarrhea virus (BVDV), *Salmonella* spp, *Escherichia-coli*, *Clostridium-perfringens*, and *Cryptosporidium- parvum*) are considered as a bottleneck in calf rearing.

### Bovine Rotavirus (BRV)

Bovine rotaviruses (BRV) of the family Reoviridae are the most common causes of diarrhea in farm animals. It is contributing significantly to enteritis and diarrhea in extensive and majorly intensively reared neonatal calves among infectious agents. The agent multiplies in the intestine and spreads with the infected animal's feces [16]. In worldwide, Bovine rotavirus is the most recognized pathogen causing acute diarrhea in cattle and buffalo calves under one month of age [17]. On other hand, it has been recognized as the major pathogen of acute diarrhea in both humans and animals. Infection can produce a complete range of clinical signs from no observed abnormality through to severe diarrhea and dehydration with a high mortality rate. Newborn calves are most prone to this disease at 8-14 days old when there is an acute

onset of diarrhea with the passage of very watery yellow/green feces with the infection spreading rapidly among young calves in the group. The disease is usually seen in young calves of 2-8 weeks of age and the susceptibility decreases as the age increases [18]. Typical signs include a reluctance to stand and suck, mild depression, and salivation at an earlier stage. This virus causes significant economic losses in neonates of many domestic animals. Besides affecting cattle and buffalo calves, rotaviruses also affect piglets, foals, lambs, kids, and young ones of pet animals and poultry [19]. Mortality in the first month of age calves is accounted to be 80 to 85% of the total mortality and is particularly high in the third week of life [20]. The severity of the disease varies, depending on age, nutritional conditions, and immunological status of the individuals affected [21].



**Figure 1:** Severe Diarrhea due to Rotavirus in calves.

### Bovine Coronavirus (BCoV)

Bovine Coronavirus (BCoV) is a member of coronaviridae family. This family belongs to the microbes that are etiologically associated with the enteric and respiratory disease across a wide range of mammalian and avian species and the most common causes of diarrhea in calves (Maclachlan and Dubovi, 2010). It usually affects calves that are between 4 and 30 days old. Generally, this virus affects cattle in three different ways and causes clinical

syndrome. This appears as diarrhea in calves, winter dysentery in mature cattle, and respiratory system infections in various categories of cattle. According to [22], coronavirus infection in newborn calves with symptoms of enterocolitis diagnosed mainly in 1-3 weeks of age. The main symptoms are diarrhea with the discharge of yellow or greenish liquid feces with a lot of mucus, sometimes mucus mixed with blood. When ulcers form on the oral cavity and oral mucosa, there is profuse salivation. The disease lasts 5-6 days. In the case of secondary microflora

complications, the lethal outcome recorded on days 2-3. Also, several phenotype and genotype indicators make it possible to distinguish between respiratory and diarrheal virus isolates. In previous studies, BCV isolation from fecal samples and nasal swabs of healthy-looking calves showed that these calves were excreted the virus in low titers and played an important role in creating clinical infections within the herd. Several epidemiologic studies have reported that high antibody titers to BCoV,

most likely resulting from exposure before weaning, can have a respiratory disease-sparing effect [23]. Coronavirus infection of the intestine in calves causes profuse watery diarrhea. Affected calves become dehydrated severely, very quickly developed fever and loss of appetite. Relatively, the incidence of diarrhea is slightly lower in neonatal calf suffered of coronavirus than rotavirus [23].



**Figure 2:** Signs of bovine Coronavirus infection in calves.

### **Bovine viral diarrhea virus (BVDV)**

Bovine viral diarrhea virus (BVDV) is a member of the family Flaviviridae and is an economically very important pathogen of cattle that is present at high prevalence in many countries around the world [24]. Although, BVDV infects various domestic and wild ruminants, cattle are the natural host developing the clinical sign of disease in the ranges of inapparent to severe, with high mortality rate and potential involvement of one or more organ systems [25]. It is one of the most economically important diseases of cattle worldwide causing direct economic losses through mortality, morbidity, premature culling, and reproductive losses including reduced conception rates, early embryonic death, abortions, congenital defects, and weak calves [26]. The most common clinical signs of acute transient postnatal infection of animals during the era when BVDV infection was emerging were reported to be

temperatures as high as 42°C, diarrhea, ulceration of the muzzle and oral cavity, and leucopenia. Few or absence of clinical signs were detected in other infected animals. Highly virulent strains of BVDV can produce lesions like those seen in cases of Mucosal disease (MD), such as severe and widespread ulceration of the oropharynx, larynx, esophagus, and hemorrhagic enteritis. Observed clinical signs consisted of inappetence, lethargy, and reduced milk yield, with a spectrum of severity. It also causes indirect economic impacts through expenditures on vaccination, individual animal testing, and other control measures [26].

The birth of persistently infected (PI) calves with BVDV resulting from in utero-fetal exposure to the virus is extremely important in the perpetuation of the virus in an infected herd and transmission of BVDV to susceptible herds through the introduction of a PI calf [27].



**Figure 3:** Signs of bovine viral diarrhea in calves.

### *Escherichia-coli* (*E. coli*)

*E. coli* is a bacterial species that are a facultative habitant of the gastrointestinal tract, and also found in the environment. However, the infection is present in cattle and other animals due to a break of the protection barrier, extreme pathogenic bacteria type- or immunosuppression. Disease due to *E. coli* in calves may be present as enteric or septicaemic illness, being one of the most important causes of neonatal mortality in dairy calves [28]. *E. coli* can be classified into six pathogroups based on their virulence scheme. Of the *E. coli* pathogroups, the most common cause of neonatal calf mortality is ETEC (Enterotoxin *Escherichia-coli*) stains that produce the K99 (F5) adhesion antigen (*E. coli* K99+) and heat-stable (STa or STb) and/or heat-labile (LT1 or LT2) enterotoxins.

The prevalence of *Escherichia Coli* varies from 5.4 to 100%, and it is roughly estimated that calf mortality associated with *E. coli* of 20% may reduce net profit to 40%. Foster and Smith, (2009) studied those neonatal calves are most susceptible to ETEC infection during the first 4 days after birth and develop “-watery”- diarrhea if infected. *E. coli* causes infection through ingestion. Following ingestion, ETEC infects the intestinal epithelium and multiplies in enterocytes in intestinal villi. This causes

watery diarrhea and weakness in 1–4-day old newborn calves. Death usually occurred within 24 hours due to severe dehydration. The fimbrial adhesion F5 (K99) promotes the adhesion of bacterial cells to glycoproteins on the epithelial surface of the jejunum and/or ileum. Bacterial enterotoxins also cause damage to the epithelial cells, resulting in fluid secretion and diarrhea (Acres, 1985).

Two of the more prominent virulence factors identified for ETEC strains are expression of fimbrial (pili) antigens that enables the bacteria to adhere to and to colonize the luminal surface of the small bowel. Secondly, elaboration of one or more enterotoxins that influence the intestinal secretion of fluids (Holland 1990). The F5 positive strains are typically isolated from calves between one and five days of age with diarrhea and it is believed that this observation is due to the decline of the expression of the F5 receptor on the bovine epithelial cells within days [29]. Other virulence factors such a sheat-stable enterotoxin (STa) and F41 may also be related to diarrhea in newborn calves. Although fimbria and enterotoxins are two known groups of the classic virulence factors. Proteomics studies have recently introduced several new proteins such as autotransporters involving in *E. coli* pathogenesis [30].



**Figure 4:** Signs of *Escherichia coli* infection with severe diarrhea in calves.

### ***Salmonella* species**

Salmonellosis is a bacterial disease responsible for causing severe economic losses due to high mortality, especially in cases of the septicemic form. The genus of *Salmonella* is divided into two species (*S. enterica* and *S. bongori*) and more than 2500 serovars. *Salmonella enterica* colonizes the digestive of both adult cattle and calves, but the infection is often recorded in the first 3 months of age and often causing severe symptoms. *S. enterica* serovar *typhimurium* (*S. typhimurium*) and serovar dublin (*S. dublin*) are known as the most common causative agents of salmonellosis in cattle causing acute and systemic diarrheal diseases, respectively [31]. The different clinical manifestations of salmonellosis include diarrhea, pneumonia, septic arthritis, meningitis, gangrene of distal extremities, tenesmus, rectal prolapse, and others, which are caused by the virulence of the serovars, infectious dose, and host immunity status. Serovars can be either host-adapted, such as bovine host-adapted *S. dublin*, or not host-adapted, such as *S. typhimurium*. Diarrhea

caused by *Salmonella* infection is characterized by watery and mucoid diarrhea with the presence of fibrin and blood. Even though *Salmonella* can cause diarrhea in both adult cattle and calves, infection is more common and often causes severe symptoms in 10-day to 3-month-old calves. On the other hand, *E. coli* K99+ causes watery diarrhea, dehydration, and weakness in 1- to 4-day-old newborn calves [32]. Diarrhea due to *Salmonella* infection is watery and mucoid with the presence of blood and fibrin. Calves can shed *Salmonella* for variable periods and intermittently depending on the degree of infection [31]. Furthermore, after the disappearance of the organism from the intestinal tract, up to 5% of recovered animals may become carriers shedding the organism in their feces. Infected cattle and carriers can serve as a source of infection for other animals or even humans through food-borne routes or direct contact and so the determination of *Salmonella* strains in fecal samples is not only important for the diagnosis of salmonellosis but also essential to identify the carriers.



**Figure 5:** Signs of salmonellosis in calves with tenesmus, rectal prolapse, and severe dehydration.

### *Clostridium Perfringens*

*Clostridium perfringens* are Gram-positive, spore-forming, anaerobic bacteria that cause a wide range of diseases in animals and 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. Among infectious causes, *C. perfringens* is of importance as a cause of enteritis and enterotoxaemia in many domestic species. Because of the widespread nature of this organism, calves are mostly exposed to *C. perfringens* in their environment and commonly ingest the bacteria in various quantities, after which it enters the stomach and intestine. Sometimes, bacteria are ingested from the feeds in sufficient quantities to cause disease, but oftentimes small quantities are ingested, followed by rapid proliferation in the intestine. Bovine necro-hemorrhagic enteritis from *Clostridium perfringens* is a common cause of sudden death with necro-hemorrhagic lesions in the small intestine. The disease typically affects neonatal calves in good to excellent body condition that are fed with a large amount of milk or milk replacer, often without showing signs of illness [33]. Infection due to *C. perfringens* type C occurs worldwide and affects several animal species. Although

several studies described the occurrence of *C. perfringens* type C infection in calves [33]. Enterotoxaemia due to *C. perfringens* is more likely to affect baby calves (within the first two months of age) than mature cattle because the calves lack a fully functioning rumen. *C. perfringens* feeds on starches and sugars in the small intestine. *Clostridium-perfringens* consists of five types of toxins, these designated A to E, which are identified based on the level of toxins they produce in animals. It is the effect of these specific toxins causing the typical clinical signs and a syndrome attributable to each type. Each toxin type of this disease is associated with specific enteric infections of various animal species [34].

The degree of causing diseases in *C. perfringens* is mediated by its intimidating arsenal of toxins and degradative enzymes. Among toxin-forming bacteria, *C. perfringens* produces at least 16 toxins and extracellular enzymes. However, none of the single strains produces this entire toxin panoply, resulting in considerable variation in the repertoire of toxins and degradative enzymes produced by different strains of this bacterium. These strain-to-strain differences in toxin production allow the classification of *C. perfringens* isolates into five toxin types (A, B, C, D, and E), based on the presence of genes encoding four so-called major toxins: alpha, beta, epsilon, and iota toxin. *C.*

*perfringens* type C can cause sudden death in neonatal calves less than 10 days of age [35]. Enterotoxaemia due to *C. perfringens* type C may result in severe bloody diarrhea, although oftentimes calves die before diarrhea develops. Varying degrees of diarrhea, and occasionally sudden onset of weakness and coma, have also been associated with type A, which generally affects a slightly older (2-4 weeks old) calf. *C. perfringens* type E is considered an infrequent cause of hemorrhagic enteritis and sudden death in neonatal calves; however, few reports also describe type E enterotoxaemia in adult cows [36].

### Cryptosporidium

*Cryptosporidium* species are among the leading causative agents of diarrhea in humans and agriculturally important livestock species throughout the world, namely calves in the first month of life. Some studies revealed that *Cryptosporidium* is the second most common pathogen causing calf diarrhea, and slightly more common in beef sucker units than in dairy herds. Three *Cryptosporidium* species are most known to cause infection in cattle these are *C. parvum*, *C. anderson*, and *C. bovis* [37]. This disease usually occurs in calves in the first 6 weeks of life and can harm weight gain and survival in the first month of life [38]. In most calves, diarrhea starts 3–5 days post-infection and lasts from 4 to 17 days. Oocyst shedding begins at 4 days after birth and peaks at 7–18 days, decreasing after 3 weeks [39]. *Cryptosporidium parvum* infection has been

most extensively studied in calves, where it has been found most often; at age one to four weeks, and causes diarrhea, weight loss, and/or impaired weight gain [37]. Among the broadly diverse pathogens that are causally linked to neonatal calf diarrhea, *Cryptosporidium parvum* is the most ubiquitously seen in several studies. Previous studies have indicated that cryptosporidiosis may occur more frequently in dairy calves than in beef calves because the former is born throughout the year and is confined to pens or hutches, which can facilitate a high level of year-round transmission [40]. During the 10–14-day-old age period most often used, neonatal calves are functional monogastric and remain so up to 4 weeks of age [41].

Experimental infections have been carried out and it has been shown that infected animals shed oocysts with no clinical manifestations of the disease in adult cows. The importance of *C. parvum* as an etiological agent of the gastroenteritis-like syndrome in dairy calves during their first weeks of life has been confirmed. Therefore, diarrhea, dehydration, weakness, anorexia, abdominal pain, and mortality are the major clinical sign observed [41]. Cryptosporidiosis has been studied in many countries and its prevalence ranges from 3.4%–96.6% in pre-weaned calves. One of the most important techniques to control diarrhea in neonatal calves is colostrum management. The passive transfer of maternal antibodies to newborn calves may minimize neonatal diarrhea caused by *C. parvum* [42].



**Figure 6:** Sign of cryptosporidiosis in one-month-old calves.

### Conclusion

Neonatal calf mortality is one of the major problems of dairy farms worldwide. The first three months of calves' life are the most critical period for the survivability of calves in any dairy farm. The mortality due to infectious diseases causes heavy losses to the farmers and industry as well as the economy worldwide. Ensuring simple managerial practices such as providing adequate intake of colostrum within the first 12 hours of life, proper housing, good hygiene to minimize disease transfer, providing clean drinking water, developing appropriate feeding protocols to encourage early rumen development and proper animal healthcare can all lead to improved calf performance and can reduce calf mortality. Thus, raising high-pedigree farm-born calves scientifically is the most profitable method of reducing herd replacement costs. Greater attention might be paid to the time of gestation of the dam, colostrum feeding, proper timing and management of calves, and hygiene of calf barns. Because of the complex nature of dairy management systems, the varieties of causes are responsible for diseases and deaths of the dairy calf.

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