AETIOPATHOLOGY OF NEONATAL CALF MORTALITY

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SUMMARY: Calf mortality has been reported to be very high in cow and buffalo neonates. This mortality has mostly been attributed to infectious agents, i.e. rotavirus, coronavirus, enteropathogenic Escherichia coli, salmonella species and cryptosporidium. Other important causes of calf mortality include immunodeficiency, seasonal effects parity of the dam, difficult parturition, sex and birth weight of the neonate and faulty management conditions. Of the infectious agents, rotavirus and E. coli are mainly involved in the causation of neonatal calf diarrhea which lead to high mortality and morbidity in young calves. E. coli mainly plays its role up to second week of life while rotavirus up to third week. Pneumonia causes great economic losses in neonatal calves. Electron microscopy is the standard technique for virus diagnosis, however, enzyme-linked immunosorbent assay (ELISA) is widely used now-a-days because of its easy handing, less technical still involved and availability.

Key Words: Aetiology and pathology of neonatal calf mortality, calf diarrhea and pneumonia.

INTRODUCTION

Diseases of the new born calf and neonatal calf mortality are the major causes of economic losses in livestock production. It is roughly estimated that a calf mortality of 20 per cent can reduce net profit to 38 per cent (9). Neonatal calf mortality varies from 8.7 to 64 per cent throughout world (Table 1). Neonatal calf mortality in the first month of age is accounted to be 84 per cent of the total mortality (27) and is particularly high in the third week (Figure 1) of life (74).

Mortality in neonatal calves has mostly been attributed to infectious agents, i.e. rotavirus, coronavirus, enteropathogenic *Escherichia coli*, salmonella species and crytosporidium (66). Other important causes of calf mortality include immunodeficiency (78), season effects (19), difficult parturition (2, 70) and faulty management conditions (17). The aim of this paper is to review the role of infectious and non-infectious agents in the aetiology and pathology of neonatal calf mortality in cows and buffaloes.

INFECTIOUS CAUSES

Aetiology of diarrhea

One of the major causes of neonatal calf mortality is diarrhea (Table 2). Diarrhea in young calves is a syndrome of great aetiological complexity. In addition to the influence of varied environmental, nutritional, physiological and management factors. The infectious agents capable of causing diarrhea in the neonatal calf are numerous. These include rotavirus, coronavirus, enteropathogenic *E. coli*, salmonella species and cryptosporidium (49, 66, 73), among which the most frequently encountered are rotavirus and enteropathogenic *E. coli* (40). In addition to these, there has been interest in campylobacters as potential causes of enteritis in calves (4) although some investigators consider that they are part of the normal enteric flora of ruminants (66).

Rotavirus

Rotavirus has an important aetiological role in the neonatal calf diarrhea (Table 3) and mainly found in faeces of diarrheic calves up to 3rd week of life (Figure 2). In 1971, Mebus and his colleagues (35) from USA first time mentioned that a viral agent is also involved in neonatal calf diarrhea. They demonstrated that the virus specially attacks the epithelium of small intestine of young calf. The virus replicates in intestinal epithelial cells near the tips of villi. Infected cells are desquamated. As epithelial cells are lost from the tips of villi, the desquamated cells are replaced by cuboidal, then flattened squamous epithelial cells. Some villi may remain denuded and stroma of villi becomes internally infiltrated with leukocytes. Later on these findings were confirmed by electron microscopy (67). Soon after the work of Mebus *et al.* (35) name 'Rotavirus' for virus involved in neonatal calf diarrhea was proposed by Flewett (20).

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Table 1: Incidence of calf mortality at different weeks of age.

Reference	Country	Incidence (%)	Age (weeks)	Buffalo / Cow calves
Freese and Gravert (21)	Germany	50	Soon after birth	Cow
Fink (19)	Germany	30.8	1	Cow
		56.4	2	Cow
Jenny *et al.* (27)	USA	19.1	4	Cow
Gusbi and Hird (23)	Libya	12.5-26	4	Cow
Verma *et al.* (75)	India	12.5	4	Buffalo
Peters (47)	UK	3.96	5	Cow
Braun and Tennant (11)	USA	18.9	5	Cow
Buhullar and Tiwana (7)	India	34	12	Buffalo
Umoh (74)	Nigeria	8.7	12	Cow
Gusbi and Hird (23)	Libya	18.8	13	Cow
Afzal *et al.* (1)	Pakistan	39.8	Before 1 Year	Buffalo
		14.3	Before 1 Year	Cow
Zrelli *et al.* (82)	Tunisia	18.8	-	Cow
McGuire *et al.* (34)	USA	64	-	Cow

Surveys on rotavirus as causative agent of neonatal calf diarrhea have been carried out in many countries like Argentina (5), Italy (14), Iraq (25), India (29), Finland (42), Japan (52), the United States (53), Germany (54), France (55), Egypt (57), Bulgaria (62), and Great Britain (80). In these surveys, the distribution of rotavirus is from 9.0 to 93.7 per cent and even in some surveys, it was as high as 100 per cent (14).

Coronavirus

Role of coronavirus in neonatal calf diarrhea was reported first time in 1972 by Stair and his colleagues (68). They demonstrated that virus has an affinity for epithelial cells of the villi of the small intestine. Replication of the virus in these cells is accompanied by loss of epithelium and blunting of the villi. In the colon, surface epithelial cells are also attacked, with loss of surface cells and cystic dilation and accumulation of cellular debris in underling crypts (36). Later on role of coronavirus in neonatal calf diarrhea was confirmed by Mebus *et al.* (37) and Sharpee *et al.* (58). Incidence of coronavirus in neonatal calf diarrhea is slightly lower than rotavirus (Table 3).

Figure 1: Age (weeks) factor in neonatal calf mortality.

Enterotoxigenic Escherichia coli

Enterotoxigenic *Escherichia coli* produces severe diarrhea in calves mainly during the first two weeks (Figure 2) of life (5) and even some reports are available that the highest frequency of *E. coli* occurs in calves younger than 3 days old (66). *E. coli* produces enterotoxic and septicemic colibacillosis in young calves (28). In enterotoxic colibacillosis, the pathogenic *E. coli* adhere to the mucosa and proliferate in the lumen of intestine, producing a potent enterotoxin, which stimulate excessive secretion of fluid from intestinal mucosa (39). This loss of fluid causes the principal sign (diarrhea) and often leads to dehydration and high rate of death in the neonatal calves (Table 2). In septicemic colibacillosis, the organisms invade the host possibly through the oral cavity, respiratory system, pharynx, or umbilicus and produces and endotoxin that apparently causes the lesions. Unless the enterotoxic form occurs simultaneously, the bacteria do not reach to the small intestine, thus diarrhea or intestinal lesions do not occur (28). Calves that are deficient in immunoglobulins are mostly susceptible to this form of colibacillosis (78). The sings and lesions are typical of bacterial arthritis, polyserositis, meningitis and pyelonephritis with bacterial emboli and necrotizing, purulent, or fibrinous exudate (81).

Incidence of *E. coli* in calf diarrhea varies very widely (Table 3). Different strains of *E. coli*, are prevalent in diarrheic calves, mostly K 99^{+} antigen was possessed by *E. coli* found involved in neonatal calf diarrhea (41, 49).

Salmonella and cryptosporidium

Salmonella infections are most frequent and of great concern to young animals. These rod-shaped, gram negative organisms are usually motile and produce gastroenteritis with nausea, vomiting, cramps and diarrhea (28), salmonella in neonatal calves (28 days old) produces diarrhea in 1 to 12 per cent calves (Tables 2 and 3) and morbidity up to 20 per cent (Table 2).

Table 2: Incidence of neonatal mortality and morbity due to different disease conditions.

Reference	Diarrhea		Pneumonia		Pneumoenteritis		Others	
	M	MB	M	MB	M	MB	M	MB
Belows *et al.* (6)	10.0	-	40.6	-	-	-	50.9[1]	-
Bullar and Tiwana (7)	63.0	-	12.0	-	9.3	-	-	-
Fink (19)	35.9	44.7	-	-	-	-	30.8[1]	24[1]
Lau (32)	23.0	-	-	-	18	-	-	-
Peters (47)	14.1	-	48.3	-	-	-	1.45[2]	-
Sangwan and Anand (50)	13.80	-	17.84	-	13.55	-	-	21.44[3]
Sharma *et al.* (59)	26.43	-	13.79	-	8.04	-	21.83[4]	-
Shimizu and nagatomo (60)	3.6	17.0	14.1	16.3	5.2	15.9	12.6[2]	20[2]
Simensen (61)	35.6	-	0.80	-	-	-	11.0[5]	-
							6.8[3]	
Varma *et al.* (75)	36.6	-	7.1	-	-	-	-	-
Williams *et al.* (79)	16.49	-	14.36	-	-	-	16.49[2]	-
Zrelli *et al.* (82)	24.5	-	34.2	-	-	-	20.5[1]	-

M: Mortality; MB: Morbidity; 1: Dystocia; 2: Salmonellosis; 3: Arthritis; 4: Milk indigestion; 5: Tympani

Cryptosporidium occurs in diarrheic calves (Table 3) and more than 10 per cent of all the scouring calves excrete cryptosporidia at the same time as rotavirus (66). In tissue sections of small intestine basophilic organisms are found embedded in microvilli of intestinal epithelial cells or just inside the cell membrane near the apical surface (45). There may be villous atrophy and cellular infiltration of lamina propria with lymphocytes and plasma cells and lesser number of neutrophils and eosinophils (33). Sings are usually unapparent but chronic diarrhea has been associated with cryptosporidiosis especially in neonatal calves (48).

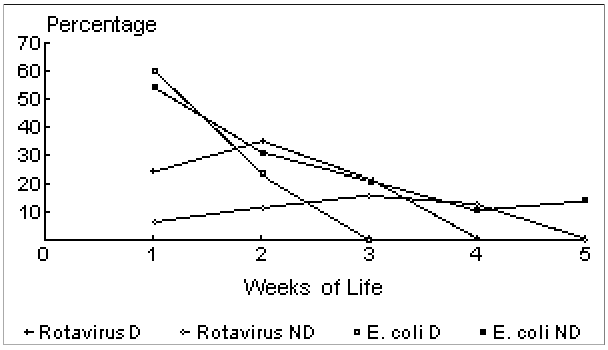

Figure 2: Incidence of rotavirus and *E. coli* in diarrheic (D) and non-diarrheic calves (ND).

Aetiology of pneumonia

Pneumonia causes great economic losses in young calves (Table 2). Two types of pneumonia namely, proliferative and exudative are prevalent in calves (72). Microorganisms yielded from nasal swabs of calves suffering from pneumonia or lung tissues from calves died of pneumonia were: *Pasteurella multocida* (60,71,72), *Pasteurella hemolytica* (71,72), *Staphylococcus epidermis* (72), *Streptococci* (60,71,72), *Pseudomonas aeuroginosa* (71), *Mycoplasma bovis* (60,71) *Corynaebacterium pyogenes* (3,71), *E. coli* (32, 71). Coronavirus (77), Herpesvirus 1 and pestivirus (24), were the viruses isolated from pneumonic lungs of calves.

Diagnosis of infectious agents

Electron microscopy is used for rotavirus and coronavirus diagnosis and remains the standard by which other assays are judged (38). However, the requirement for expensive equipment with skilled operation limits its use. Further, with this method, it is also difficult to handle large number of specimens.

The demonstration of rotavirus double-standard RNA in silver-stained polyacrylamide gels is an other well recognized method for diagnosing rotavirus infections (26). This technique also requires special equipment. The tests like immunodiffussion (29), neutralization of indirect immunofluorescence (54, 65), complement fixation (57), fluorescent antibody staining (57), agar gel precipitation (25, 57), immunoelectrophoresis (25) and hemagglutination (65) are also being used for the detection of rotavirus and coronavirus from faeces of the diarrheic calves. Latex agglutination (56) and enzyme-linked immunosorbent assay (ELISA) are widely applied for diagnosis of rotavirus and coronavirus (49, 56). ELISA kits are widely available and are often used. All these are recommended to be read by spectrophotometer with visual reading possible, albeit with minor lower sensitivity, if suitable facilities do not exist (38).

Escherichia coli and salmonella species could be isolated from diarrheic samples as well from the suspected materials like nasal discharge or lung tissue from pneumonic lungs of calves, by following standard techniques of isolation (15). Diagnosis of cryptosporidium could be made by staining the faecal smears of diarrheic calves with methylene saffrainin blue stain and examination under microscope (22).

Table 3: Prevalence (%) of rotavirus, coronavirus, *E. coli*, cryptosporidium and salmonella in diarrheic calves.

Reference	1	2	3	4	5
Barrandeguy *et al.* (5)	27.0	-	30.00	5.00	10.00
Bordas *et al.* (10)	50.0	20.0	33.00	9.6	-
Buhr-Pohlmann (13)	9.0	-	33.00	3.00	12.00
Castrucci *et al.* (14)	100	-	-	-	-
Debnath *et al.* (16)	10.0	-	20.00	-	3.00
Fiedler *et al.* (18)	1.96	-	-	37.6	0.39
Hasso *et al.* (25)	26.0	-	-	-	-
Kaushik *et al.* (29)	45.45	-	-	-	-
Nagy *et al.* (41)	40.00	15.00	50.00	27.00	0.0
Neuvonen *et al.* (42)	93.7	-	-	-	-
Reynolds *et al.* (49)	42.0	14.00	3.00	21.00	12.00
Schulz (54)	38.8	32.00	-	-	-
Shalaby *et al.* (57)	48.0	-	-	-	-
Simeonov *et al.* (62)	42.0	54.00	51.00	-	-
Sizov *et al.* (64)	57.0	-	34.00	-	-
Snodgrass *et al.* (66)	35.43	3.64	3.64	12.91	0.66

1: Rotavirus; 2: Coroavirus; 3: E. coli; 4: Cryptosporidium; 5: Salmonella

NON-INFECTIOUS CAUSES

Immunoglobulin

Relationship of immunoglobulins with neonatal calf mortality has been discussed in detail elsewhere (31). Immunoglobulins are acquired by the offspring through the agency of colostrum. In colostrum, immunoglobulins present are IgG_1, IgM, IgA and IgG_2, however, IgG_1 is predominant representing 80 per cent of the total immunoglobulins absorbed by the neonatal calf (8). Immunoglobulins from the colostrum absorb into the circulation from the small intestines of the neonatal calf by a process micropinocytosis (9). Maximum absorption occurs within the first 6-8 hours after birth (8). The amount of antibodies from individual females show differences due to breed, nutritional status and parity. Season, geography, and sex is also known to influence passive transfer of colostral immunoglobulins in calves (51). During absorptive period, competition between microorganisms and immunoglobulins does occur for intestinal receptors for transportation to the circulation. Intestinal bacteria produce malabsorption syndrome by occupying immunoglobulins receptors resulting in hypo or agammaglobulinemia in neonatal calves (66).

Colostral immunoglobulins present in the intestine and subsequently absorbed in to the circulation protect neonatal calves against enteric and respiratory diseases and even from leg injuries (43). High mortality and morbidity due to diarrhea, pneumonia and other diseases occurs in immunodeficient calves (11, 31). Calves without adequate circulating IgG_1 are four time more likely to die and twice as likely to become ill than calves with adequate circulating immunoglobulins (78).

Season

Season has a significant effect on the calf mortality (19) as well as on the absorption of immunoglobulins in neonatal calves. In temperate climates the mean serum IgG_1 concentrations were lowest in winter born calves and increased during the spring and early summer (43), perhaps this is the reason that higher mortality rates of 69.6 and 15.36 per cent had been observed in winter born buffalo calves than 39.4 and 5.97 per cent in summer born calves (1,59). Similar observations have been reported by other workers (7, 75).

Parturition problems and parity

Dystocia (Table 2) in the dams increases the rate of mortality in neonates. About 50 per cent calves are lost at parturition due to dystocia (6). Dystocia is mainly due to abnormal presentation of calf especially backward and breech presentation. Incidence of dystocia is higher (5.6%) in primiparous dams (Figure 3) than (0.9%) in multiparous dams and is also significantly higher ($p<0.01$) when the calf is male (57.6%) but lowered (42.4%) when the calf is female (46). Persistent hymen in heifers is an important condition which delays the delivery of the young one in naturally bred heifers (2). According to Jenny and his colleagues (27), stillborn calves are more likely to die as compared to normal delivered calves. Stillbirths varies with the parity of the dam (61) and season of the year (70). In primiparous cows and during winter, stillbirths were higher than in multiparous cows and summer season. There is another factor i.e., sex which increases the rate of stillbirths in male calves (70).

As parturition problem decreases with age and parity of the dam, the amount of colostrum available and concentration of colostral immunoglobulins increases (51). Studies conducted by Odde (44) manifested immune status to be better in calves from multiparous than primiparous dams. When there is better immune status of calf, its survival will not be affected by the gastrointestinal or respiratory diseases.

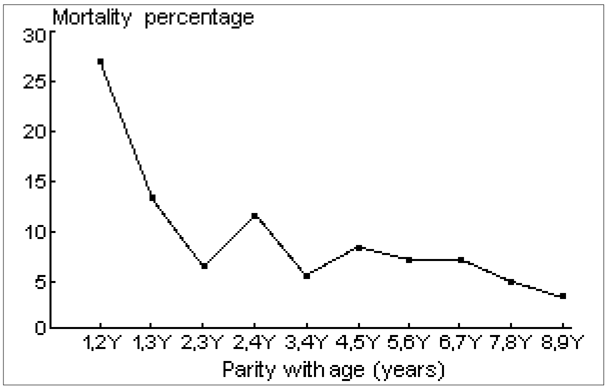

Figure 3: Calf death by damage and parity.

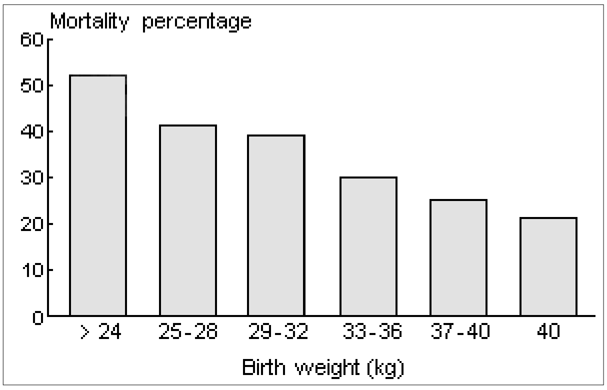

Figure 4: Birth weight of neonatal affecting the neonatal calf mortality.

Sex and birth weight of calf

Mortality is higher in male 25.5%) than in female (13.9%) neonatal calves (30), reason for this higher mortality might be due to serum immunoglobulins, required for the protection from different diseases during neonatal life, absorb less in male (20.69 mg/ml) than female (25.12 mg/ml) calves (51). Competition between microorganisms and immunoglobulins for a common intestinal receptor does occur in early few hours of life (69), due to this competition male calves become more immunodeficient than female calves, therefore, former calves (59.42%) are more prone to bacterial diseases than later (50%) neonatal calves (30). Stillbirths as well as dystocia problems are more common when male calves are involved (46, 70).

The birth weight had a significant effect on mortality. Calf mortality decreases gradually with increase in birth weight (Figure 4) and minimum (21.1%) in calves weighing 41 kg and above at birth (7). Similar observations about birth weight of calves have been reported by Singh *et al.* (63). There is also difference of opinion, as Verma *et al.* (76) reported non-significant effect of birth weight of calves on calf mortality. Male calves had a significant higher (37.2 kg) body weight than female (33.7 kg) calves (6), perhaps this is the reason that dystocia is more common when the sex of the calf is male (46).

Management and miscellaneous factors

In calf houses, poor ventilation, overcrowding, no regular cleaning and disinfection predispose various diseases of calves, especially of respiratory tract leading to high calf mortality (17). Tympani and milk indigestion also play an active role in the neonatal calf mortality (Table 2). Absorption of immunoglobulins continue up to 48 hours in calves, but maximum absorption occurs within the first 6-8 hours of life (8), if feeding of colostrum is delayed from this period, it results in hypo or agammaglobulinemia in calves (34). Compared to hand feeding, suckling is a greater source of absorption of colostral immunoglobulins, therefore, it is generally recommended to allow calf to suckle its mother for the first two days post partum (8).

Calves kept in pens develop arthritis, tendovaginitis or abscesses and even fractures and those develop naval joint illness had a poor survival rates (12). Mortality of calves can be reduced by rearing them on elevated and perforated floors (61). Similarly naval disinfection and removal of mucous from the mouth and nose reduces mortality and morbidity rates in calves (19).

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