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A Review of the Relationship Between Persistent Infection of Cattle with Bovine Viral Diarrhea Virus and Feedlot Morbidity and Gain

Larry Moczygemba, *DVM*
South Texas Veterinary Clinic, RR 3 Box 293, Beeville, Texas 78102

Abstract

Bovine viral diarrhea is an infectious viral disease of cattle. Persistently infected cattle result from *in-utero* infection of calves with the bovine viral diarrhea virus during critical stages of gestation, and affected calves become lifetime carriers of the virus. Cattle persistently infected with the virus can be a source of infection to healthy pen mates in a feedlot setting. The feedlot industry is a cost-driven, low-margin business, and cattle need to perform efficiently to be profitable. Morbidity can have a significant impact on profitability. This paper reviews the relationship between calves persistently infected with bovine viral diarrhea virus and the health and performance of feedlot cattle at the pen level.

Résumé

La diarrhée virale bovine est une maladie infectieuse virale des bovins. L'infection persistante des bovins résulte de l'infection intra-utérine des veaux avec le virus de la diarrhée virale bovine durant les périodes critiques de la gestation. Les veaux ainsi infectés deviennent des porteurs du virus pendant toute leur vie. Les bovins infectés de manière persistante peuvent devenir une source d'infection pour les individus partageant les mêmes enclos dans un parc d'engraissement. L'industrie des parcs d'engraissement est sensible aux coûts et possède une faible marge de manœuvre. Il est donc important que le bétail donne un bon rendement pour la rendre profitable. Le taux de morbidité peut avoir un profond impact sur la rentabilité. Cet article fait le point sur la relation entre l'infection persistante des veaux avec le virus de la diarrhée virale bovine, l'état de santé et la performance du bétail dans les parcs d'engraissement au niveau de l'enclos.

Introduction

Bovine viral diarrhea virus (BVDV), a pestivirus first described in the 1940s in New York,[65] has been described extensively in the literature, and has been characterized as the most economically important viral disease of cattle in the United States.[46] The extreme variability and mutagenicity of the BVDV have contributed to the difficulty in understanding the disease complex. With the advent of newer diagnostic techniques to identify cattle infected with the virus, we have a better understanding of the economic impact of the virus and its ubiquitous nature.

While the serologic prevalence of BVDV is estimated between 50 and 90%,[11] a syndrome has been described where animals become persistently infected (PI) with the virus. The prevalence of PI animals in the beef cattle population has been estimated at 1%.[11,42] These animals are the primary reservoir for the virus and play an important role in maintenance of the virus within a herd.[46] The virus is transmitted both vertically and horizontally;[17,34,57,88,90,97,98] however, acutely infected animals are not believed to be a significant source of viral transmission to susceptible penmates, and as a result, the majority of control programs prioritize removal of PI animals as the primary means of establishing a BVDV-free herd.[32,35,36,37,79]

The BVDV has long been recognized as an endemic problem at the cow/calf level, especially as a cause of intestinal and reproductive disease; more recently it has been reported to be a major respiratory pathogen in the Bovine Respiratory Disease (BRD) complex.[19,55,68,69,70,75,78,87] BRD is the leading cause of feedlot morbidity and mortality.[26,53,54,67] While it is controversial whether morbidity leads to decreased performance, or if cattle with substandard performance are more likely to become sick, one review found an established nega-

tive association between morbidity and performance.[83] Another report suggested that morbidity has a greater negative impact on growth performance than any other factor.[59] The beef industry has attempted to control morbidity either through preconditioning and/or processing programs (e.g., vaccination), or attempting to minimize pathogen exposure and stress.

The purpose of this literature review was to summarize the potential negative impact of persistent infection of calves with BVDV, at the pen level, on feedlot health and growth performance of calves determined to be PI, and their susceptible penmates. Unfortunately, no reports were found in the literature that specifically reported this effect. Therefore, as a framework for a literature search on this hypothesis, three pivotal questions were asked, and the literature was searched in an attempt to answer them:

1) What is the prevalence of BVDV infection and PI calves within a population?

2) What is the infectivity of BVDV shed from a PI calf to a susceptible calf?

3) What is the economic impact of BVD-associated morbidity on feedlot performance?

Prior to discussing these three questions, a review of etiopathogenesis and clinical disease caused by BVDV is indicated.

Bovine Viral Diarrhea – Etiopathogenesis

BVDV is an RNA virus that belongs to the genus Pestivirus, family Togaviridae. There are two biotypes of BVDV: cytopathic, which kills infected cells in tissue culture, and noncytopathic, which does not.[1,7,52] Emphasis is placed on differentiating Type I BVDV from Type II BVDV, but this differentiation is based on genotypic differences in the 5' untranslated region of the viral genome, and both cytopathic and noncytopathic variants can exist within each group.[6,66] Transmission of the virus can be either horizontal or vertical.[3,20,60,95] One of the major peculiarities of the noncytopathic virus is its ability to cause a PI state by infecting the fetus between 45 and 120 days of gestation.[21,36,46] PI calves have no neutralizing antibody to the homologous virus at birth, and continue to carry the virus throughout their lifetime.

The neonatal mortality rate of PI calves is higher than the normal population, and they often are born weak with limited survivability compared to uninfected normal calves.[5,46,56] In contrast, some PI animals grow normally following birth, although there may be histological changes present.[10,37,40,89] Testing of over 1500 bulls in four artificial insemination centers found 12 PI animals.[41] One final sequela to the original viral exposure of the pregnant dam is mucosal disease (MD), which refers to a fatal condition resulting from exposure of a PI calf later in life to an antigenically similar cytopathic strain of BVDV.[8,12,16,22,50,61,91]

Clinical Disease

An estimated 70-90% of BVDV infections in susceptible, immunocompetent cattle are subclinical.[1,73] These animals exhibit mild elevation of body temperature and leukopenia, followed by development of neutralizing antibody. Clinical infections are most common in cattle 6-24 months of age; morbidity is high and mortality low. Clinical signs include depression, anorexia, oculonasal discharge and occasional oral lesions.[2,73] One consistent feature of BVDV infection, however, is immunosuppression.[44,81,82] Leukopenia, suppressed B- and T-lymphocyte function, neutrophil and monocyte depression (both number and function), and ultimately lymphoid depletion have all been reported.[9,33,52,77] The exception to this acute, infective state is a chronic condition such as occurs with the PI calf.[10] Mucosal disease, as previously defined, can also develop into a chronic disease syndrome.[64]

Reports suggest that BVDV infection may potentiate or enhance the pathogenicity of co-infecting pathogens such as *Pasteurella* spp, parainfluenza virus-type 3 and many others.[30,52,71,92,96,102] One study reported no association between BVDV and the mean clearance of Pasteurella (*Mannheimia haemolytica*) from the lungs.[51] In contrast, later studies reported a synergism between BVDV and *M. haemolytica*.[28,58,76] Another review concluded that BVDV may play a "pivotal" role in the BRD complex, namely due to its immunosuppressive effect.[68] One controversial thought is that strains of BVDV differ in their pneumopathogenicity, and that the cytopathic biotype is associated with more severe disease.[24,72]

Bovine Viral Diarrhea – Prevalence

To address the first question in this literature review, the literature was searched to define the prevalence of BVDV infection in the beef cattle population, and more specifically the prevalence of PI calves. Prevalence refers to a "snapshot" of the number of diseased animals present at one point in time. The prevalence of BVDV infection (excluding PI animals) varies greatly, depending on whether the sampling time frame coincides with acute viremia within the studied population. In contrast, because the PI state is permanent, the prevalence of PI calves is more static. PI calves are believed to represent a significant source of viral transmission to susceptible calves,[73,100] and thus, their prevalence is of greater interest.

The true prevalence of PI calves is controversial, with reports varying between countries and geographic regions. One US study reported 1.7-1.9% of cattle in selected beef herds were PI.[11] In terms of herd prevalence, a US study found that 3% of randomly selected beef herds had calves with confirmed persistent BVDV

infections.[99] A later study of dairy cattle in the US found PI calves in 15% of herds sampled, and the prevalence of PI calves was 0.13% of the population sampled.[38] Canadian researchers reported fewer than 0.1% of feedlot cattle were PI, but suggested the findings may have been biased due to purchasing practices by the feedlot examined, or the possibility of problems with the tests employed.[89] A British study reported that 1.8% of cattle were viremic at slaughter, although the animals were not proven to be PI.[25] Similarly, Denmark scientists reported that 0.9% of healthy cattle were viremic at slaughter, but the definition of PI was not described.[35] One would not expect BVDV to manifest itself as an acute viremia in cattle ready for harvest, therefore it is possible that these animals were PI with the BVDV. This cannot be proven with the information reported, however, the percentages are consistent with those reported elsewhere for PI animals.

It is apparent from the studies reviewed that the prevalence of PI calves is low, but variable. One of the biggest problems in estimating prevalence is the lack of standardized testing to identify PI animals. Many reports questioned the testing method of published studies. Early studies looked for antibodies in unvaccinated animals 6-18 months of age. Houe showed a high probability of finding BVDV antibodies if a PI animal was present in the group, and recommended this as a screening procedure.[39] Initially, PI calves were thought to be immuno-tolerant, and could not respond to antigenic stimulation. As a result, antibody-free animals in a herd where infection was documented were considered immunotolerant, and thus persistently infected.[a] Later work showed this phenomenon to be variable, and made antibody testing to identify PI animals questionable, unless these antibody-free animals were confirmed by virus isolation, prior to being classified as persistently infected.[46]

The original gold-standard test for diagnosing persistent infection was two consecutive positive virus isolation tests, which helped differentiate acute infection from persistent infection. While serum is best suited for BVDV screening of cattle greater than four months old, results of a recent study indicate that rarely, persistently infected adult cattle may develop antibodies against BVDV that lead to the clearance of virus from serum, but not white blood cells.[13] The prevalence of cattle persistently infected with BVDV that have a negative immunoperoxidase microtiter assay (IPMA) for virus isolation on serum is extremely low. These IPMA negative PI animals are a reservoir of infection to susceptible penmates, however.[32]

Immunohistochemical (IHC) staining of formalin-fixed skin biopsies has recently been described to be a fast and efficient test for the practicing veterinarian.[63] Prior to this, the predominant tests to diagnose persistent infections were the antigen-ELISA and virus isolation.[23] Ag-ELISA is a reliable test to detect PI animals, but has not been evaluated to differentiate transient infections. Virus isolation, however, is considered to be more sensitive than Ag-ELISA.[86] A recent study suggested that IHC testing may be more sensitive than microtiter plate virus isolation (MPVI), even though MPVI is almost 100% sensitive.[94] Collection of samples for IHC staining is as easy as for MPVI, but is more stable under field conditions since it is a formalin-fixed sample not requiring refrigeration. Sample stability is thought to influence the difference in sensitivity,[15] although one small study found no difference in virus detection *via* virus isolation following a delay of up to five days between sample collection and testing.[74] IHC is more specific in terms of identifying PI animals, however, because only a single test is required. In summary, some diagnosticians consider the IHC test to be nearly 100% sensitive and specific for identifying PI animals with a single sample.[b] With the advent and acceptance of immunohistochemical staining of formalin-fixed skin biopsies, future studies may provide a more accurate estimate of the prevalence of PI cattle.

Bovine Viral Diarrhea Virus - Infectivity

Although BVDV is transmitted both horizontally and vertically, vertical transmission occurs less frequently than horizontal, and PI calves are thought to be the most important source of transmission to susceptible animals.[46] PI calves transmit the virus efficiently, shedding large quantities of virus into the environment over prolonged periods of time, and spread to susceptible cattle is rapid.[37] Accordingly, most control/eradication programs are aimed primarily at the removal of PI animals.[32,36,37,47,79] One study showed inefficient virus transmission from acutely infected BVDV calves to susceptible penmates, but found PI calves to be efficient transmitters of the virus.[62] While most reports suggest that PI cattle shed the virus continuously, others suggest that the levels of viremia, and subsequent shedding, change over time.[32] Stress may potentiate viremia and shedding.[13] Current understanding suggests that while PI cattle are immunotolerant to BVDV strains that are homologous to that which infected them *in-utero*, PI animals may be able to mount an immune response to specific heterologous BVDV antigens over time. One researcher reported that viremia in PI cattle can become undetectable by virus isolation from serum due to the development of virus neutralizing antibody.[14] My literature search did not reveal any studies that documented a consistent level of viremia over an extended period of time. Brock *et al* suggested, however, that levels of viremia in PI calves are cyclic, and calves may have higher levels of virus and thus shed more

under certain stressful conditions, like those encountered at feedlot entry.[13]

Morbidity – Economic Impact

The final question addressed in this literature review was the economic impact of BVD on feedlot morbidity and performance. The feedlot industry is a cost-driven, low-margin business. While mortality has a negative economic impact, losses associated with high morbidity rates can be equally costly.[80] Sick calves incur expenses due to medication and labor involved with treatment, premature culling due to chronic conditions, and most importantly the expense of reduced growth and performance during and after the illness.[4,93,100,101] One study showed no effect on performance parameters between sick cattle and apparently healthy cattle, but the authors felt the disease challenge in their study was not adequate to demonstrate differences.[43]

Average medicine cost to treat BRD has been reported to be $27/animal treated.[18] Morbidity percentages vary between 15 and 45% of incoming cattle.[48] With high-risk cattle, if we assume that 30% of the cattle coming into a feedyard require treatment at $27/animal treated, medical costs are significant. Additionally, not all treated animals recover. Many feedlots discontinue treatment after two or three courses of therapy, and consider the animal non-responsive or "chronic".[45] These chronic animals are often sold at a loss or euthanized. Estimates of "chronic percentages" range from 2 to 15% of treated cattle.[18] Death loss ranges from 1 to 5% of incoming cattle.[48]

Studies have shown that treatment of feedlot cattle with BRD may not prevent associated production losses.[29] In Texas A&M University Ranch to Rail studies, cattle that had been sick and treated gained 7.7% less weight than cattle not identified as sick, and cost of gain was 18% higher.[85] Texas researchers reported the total cost of sick cattle to be $111.38/head treated.[18] Other studies reported that average daily gain of treated cattle was from 0.31-0.51 lb (0.14-0.23 kg) per day less for the first 28 days than those not treated.[4,84] Differences in ADG between treated and untreated cattle can persist until closeout when cattle are sold at harvest.[4] Several studies showed ADG was decreased from 0.13-0.19 lb (0.06-0.09 kg) per day for sick cattle compared to those not sick.[4,18,29,84] In addition, lung lesions resulting from BRD have been linked to decreased cattle performance and/or a lower quality grade,[4,29,31,59,84] although other studies failed to show this association.[27,49]

Discussion

BVDV has been discussed and studied for the last 60 years, therefore it was disappointing to find a lack of published studies about the impact of BVDV infection, and specifically PI animals, on feedlot health and growth performance. As such, the literature search was confined to three areas: 1) the prevalence of BVDV-PI animals; 2) the infectivity of a PI animal; and 3) the impact of morbidity on feedlot health and growth performance.

The true prevalence of PI calves is still in doubt due to the limitations of older diagnostic tests discussed earlier. Additionally, there are no conclusive data describing transmission of BVDV from a PI calf to a large population of cattle, as could occur in a feedlot setting. Numerous reports were found that showed transmission is not only real, but transmission of the virus from PI animals to susceptible ones is the major mode of transmitting BVDV. Yet, this has not been investigated on a large scale. Finally, there are a large number of articles that support the conclusion that sickness has a negative impact on feedlot health and growth performance.

Conclusions

The importance of bovine viral diarrhea virus as a major pathogen of cattle has been well documented. Persistently infected cattle play a major role in spread of the disease, and most control programs prioritize their removal. The prevalence of persistently infected beef cattle is varied, but an accurate rate is not available. Diagnostic tests used to classify cattle as persistently infected have been controversial, but new tests show promise to be more accurate. The infectivity of persistently infected cattle to healthy pen mates in a feedlot setting has not been well documented. The intent of this literature review was to show an association between feedlot performance/profitability and bovine viral diarrhea caused by persistently infected calves. However, the literature failed to support this hypothesis.

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Footnotes

[a]Robert Sprowls, Texas Veterinary Medical Diagnostic Laboratory, personal communication, 2003.
[b]B.W. Broderson, University of Nebraska, personal communication, 2002.

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Abstracts

The Effect of Feeding Anionic Salts on Urine pH

J.A. Husband, M.J. Green, N.N. Jonsson

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Anionic salts can have a beneficial effect on calcium homeostasis by inducing a mild metabolic acidosis. This causes a fall in urine pH which can be used to monitor the effects of the salts. In a pilot study, 20 cows in the last 3 weeks of gestation were matched according to parity and previous yield into anionic salt supplemented and control groups. Individual urine pHs fell within 2 days in the supplemented group but a consistent group response took approximately 7 days. In the main study, 38 cows were similarly matched but a 2 kg premix was used to incorporate the anionic salts instead of a mixer wagon. The larger variability of urinary pH in the main study compared with the pilot study was consistent with a greater variation in anionic salt intake in the main study, probably due to the use of a premix rather than a mixer wagon to administer the salts.

The conclusions of the study highlighted important practical points concerning the feeding of anionic salts. Firstly, the salts need to be fed for at least 7 days for a consistent urinary pH response in a group. Secondly, the use of a mixer wagon to incorporate the salts into the ration reduces variability in anionic salt intake and consequently urinary pH variability.

Factors Affecting Colostrum Quality

Tittle D.J.

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Colostrum samples were collected from 14 postpartum cows, which had suckled their young. Blood was collected from their calves approximately 36 hours after birth. ELISAs were run on both whole colostrum and calf serum to determine levels of IgGl, and antibodies to the bovine respiratory viruses: IBR, PIS, and BRSV. No correlation was found between colostral quality and subsequent immune status, as determined by these factors. No relationship was found between factors such as third milking yield and colostral IgGl concentration, lactation number and colostral IgGl concentration, or previous 305 day yield and colostral IgGl concentration. However, the methods used in determining IgGl and specific antibody levels were novel with regard to their use with whole colostrum, and provide potential for their use in determining colostral quality, prior to feeding to calves, or placement in colostrum banks.