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INTRODUCTION

Bovine viral diarrhea (BVD) is a common viral infection of cattle worldwide. The viruses responsible for BVD are classified as pestiviruses, a group of viruses that includes BVDV type I and type II, Border disease virus of sheep and hog cholera virus. Although BVD was first recognized as a disease of cattle 50 years ago, the genetics and epidemiology of BVD viruses have only been well-described in the last 10 years. These scientific advances have increased the accuracy of diagnostic testing for BVD and clarified the diseases caused by BVD viruses.

BVD is a confusing topic because the viruses cause a variety of diseases including diarrhea, hemorrhagic syndrome, peracute death syndrome, mucosal disease, infertility, abortions and weak calves. Producers can use new information about BVD viruses and their transmission to prevent the introduction of BVD into beef herds or eliminate BVD viruses from infected herds.

TRANSMISSION OF BVD VIRUSES

There are two modes of BVD virus transmission: **1) acute** or **postnatal** infections and **2) fetal** infections. In the acute, postnatal infection, BVD virus is transmitted in nasal secretions from an infected calf to others much like common cold viruses are transmitted between children. In most cases, the infection results in fever and mild diarrhea. The calf develops an immune response to the BVD virus and clears the virus without residual problems. Fortunately, acutely infected animals shed small amounts of virus and are inefficient transmitters of BVD viruses. Transmission of BVD from acutely infected calves is of greatest importance in crowded conditions such as feedlots and veal calf barns.

The second mode of transmission is from the cow to her fetus. These fetal infections have the most important consequences for beef herds. When a cow with no previous immunity to BVD comes in contact with an infected animal, some of the white blood cells in her nose and throat become infected and enter the blood. Once in the bloodstream, BVD viruses are highly successful at crossing the placenta and infecting the fetus. Infections during the first trimester of pregnancy can result in the birth of live calves who are persistently infected (**PI**) with BVD virus (4). PIs shed high amounts of virus throughout their lifetime and are a continual source of BVD infection in a herd (3).

DISEASES CAUSED BY BVD VIRUSES

1. Postnatal infections: In addition to mild diarrhea and fever, it is now recognized that there are some BVD viruses that can cause severe disease. BVD viruses infect cells in the bone

marrow including megakaryocytes, the cells that produce platelets. Platelets are important in blood clotting. When platelet numbers are severely depressed as in these BVD infections, blood loss occurs from many small vessels in muscles and internal organs leading to death. This hemorrhagic condition in veal calves was first described in the 1980's (2).

Peracute deaths in adult cattle in Ontario, Canada were first described in 1993 (1). Infected cattle developed high fevers (106-107° F), signs of respiratory distress and diarrhea, and died within 24 to 48 hours of the onset of illness. When the genetic sequences of these BVD viruses were examined, it became clear that they were different than BVD viruses previously used in research and diagnostic labs. These viruses were called **Type II** to distinguish them from more familiar **Type I** strains of BVD (6).

Since 1994, both Type I and Type II BVDV viruses have been isolated from western beef herds (10). The Type II viruses isolated from Wyoming cattle do not appear to cause peracute deaths and are associated with similar diseases caused by Type I BVD.

BVD infections also depress a calf's immune system leading to a greater susceptibility to other infections. For example, a common complication of BVD infections is a severe form of *Pasteurella* pneumonia that is unresponsive to antibiotic treatment. Other illnesses compounded by the immunosuppressive effects of BVD viruses are of considerable economic importance at all stages of beef production.

2. Fetal infections: The outcome of BVDV infection depends on the age of the fetus and the strain of BVD virus. If infection occurs in the first 2, months of pregnancy, the loss of the fetus may only be noticed as a return to heat (5), or as a prolonged calving period the following spring.

Development of the specific immune response in the fetus occurs sometime between 125-150 days of gestation. Therefore, fetuses infected in the first 90 to 120 days of pregnancy may not recognize BVD virus as a foreign invader. Should these fetuses survive to term, they will be "immunotolerant" to the BVD virus and never clear the infection. These calves will be born PI and remain so throughout their lives. If the dam is a PI animal, she will always produce PI calves. However, most PIs are born to normal cows which have been acutely infected with BVD virus during the first trimester of pregnancy.

Fetuses infected between 80 and 100 days of pregnancy may be born with abnormalities of the brain and eyes. After 150 days, the fetus is able to develop an immune response to BVD and will be born with antibodies to BVD virus. Infection of the fetus anytime during gestationcan result in fetal death and abortion much later in pregnancy. This explains why infection of the cow during the summer may result in an increased percentage of open cows at fall pregnancy check, and late term abortions, stillbirths and weak, poor-doing calves the following spring.

3. Mucosal disease: PI animals tend to be poor-doers, have no antibodies to their BVD virus and eventually die at a young age (9). The majority of PIs die due to an intractable form of diarrhea known as **mucosal disease (MD)**. Cattle with MD exhibit fever and severe diarrhea

often containing blood, mucus and intestinal tissue. These calves will have ulcers in their mouth and gastrointestinal tract. The diarrhea may have a short or protracted course.

MD is a virological curiosity which appears to occur when a PI animal acquires a second BVD infection. This second infection in most cases occurs when the **noncytopathic** BVD virus within the animal mutates and forms a **cytopathic** variant - a mutant that kills bovine cells in culture. Another way in which a PI acquires a second infection with a cytopathic strain of BVD virus is through vaccination with modified-live (MLV)-BVD viral vaccines that contain cytopathic BVD viruses.

Although MD is usually only a sporadic occurrence, the disease is important because it is an indicator of BVD infection in a herd. One way in which a herd is recognized to have BVD occurs when a MLV-BVD vaccine is first used in calves and deaths occur due to vaccine-induced MD.

EPIDEMIOLOGY OF BVD IN BEEF HERDS

When a cow herd is first exposed to a BVD virus, the effects on reproduction can be devastating with 10% or greater open cows, abortions or weak, non-viable calves. This is known as the **epidemic** form of BVD (3). There are two possible outcomes to a BVD epidemic. If no PI calves are born following infection, then the virus infection will not continue in the herd. If, however, one or more PI calves are born and remain in the herd through the summer, then they can serve as a continuing source of infection for susceptible cows. When this cycle of fetal infection is perpetuated, then the herd has entered a state of **endemic** BVD (3).

As cows are repeatedly exposed to the virus by contact with PIs within the herd, their immunity to that specific BVD virus increases. Therefore, older cows are less likely to abort in following years. In these infected herds, the group most likely to have problems are the first calf heifers due to lack of previous exposure to BVD. Heifers are particularly vulnerable if they are purchased from herds without BVD or are raised separately from the cows and calves in BVD-infected herds.

BVD viruses will continue to circulate in a beef herd as long as there is a PI present to serve as a source of virus for susceptible heifers and cows. In beef herds, BVD infection can be maintained by PI calves of the current year's crop (9). PIs rarely survive long enough to enter the breeding herd and usually make up less than 0.5% of adult cows.

Since the discovery of Type II BVD viruses, scientists have found that BVD viruses are genetically very diverse. In addition to genetic differences between Type I and Type II BVD viruses, BVD viruses also vary within each type. This genetic variation is reflected in **antigenic variation** or differences recognized by the cow's immune system. These differences are important when discussing the effectiveness of BVD vaccines for the prevention of BVD infections.

DIAGNOSIS OF BVD

Nutrition, environmental factors, bacteria and other viruses can also cause infertility, abortions and weak calves. Therefore, it is important to have an accurate diagnosis of BVD before formulating a plan to eliminate the virus from a herd. Direct evidence of BVD infection in a herd is provided by **virus isolation** from the blood of a PI animal, tissues from an aborted fetuses, or weak calves. The genetic material of BVD may be detected by polymerase chain reaction (**PCR**), a sensitive and specific technique. Viral proteins can be detected in tissues by BVD-specific antibodies tagged with a fluorescent dye (**FA test**) or an enzyme **immunocytochemistry**) .

Abortions and weak calves often occur long after the BVD infection. After this period of time, BVD virus, proteins and genes may no longer be detectable particularly if the infection occurred after 100 days of gestation. Finding evidence of the virus infection is not possible in every case. There are several things that producers can do to increase the chances of making a diagnosis in any abortion or dead calf. Keep the specimen as clean as possible (place smaller fetuses in plastic bags), store at refrigerator temperature (**do not freeze**), and deliver the specimen to your veterinarian as soon as possible. Producers need to work with their veterinarians and submit tissues from as many aborted fetuses, weak or sick calves as possible. Perseverance is important in establishing BVD viruses as a cause of reproductive losses.

Indirect evidence of BVD infection is provided by **serum neutralizing antibody** (**SN**) **titers** in any unvaccinated cattle. SN titers are a measurement of the concentration of specific antibodies and indicate previous infection. Finding BVD SN titers in unvaccinated cattle is a clear indicator of BVD infection. However, beef herds that do not use BVD vaccines are a rarity, and most adult cattle have antibodies to BVD. In addition, calves will have BVD SN titers after ingesting colostrum from vaccinated cows. These vaccine-induced BVD antibodies complicate the diagnosis of BVD infection. Serum samples taken at the time of abortion and 2 to 3 weeks later are of limited usefulness since the virus infection may occur weeks to months prior to the abortion.

Cows that have received multiple MLV-BVD vaccinations maintain high SN titers throughout their life. In contrast, maternally derived antibodies in calves decay over time and at weaning antibody titers are quite low. Calves can make their own BVD antibodies any time after 150 days of gestation. These actively acquired antibodies will persist even after maternal antibodies have declined. Therefore, measuring BVD antibodies in calves at weaning prior to vaccination can distinguish the infection status of a herd. In herds containing PIs, a high proportion of weaned calves will have BVD SN titers greater than or equal to 1:1024 (11).

When BVD infection has been diagnosed in a beef herd, the herd should be screened for PIs. A blood test called the "BVD ELISA" can used to identify PIs (8). This test is works on the same principles as virus isolation. A very small amount of serum or plasma is mixed with susceptible bovine cells. If BVD is present in blood as is the case for PIs, then the virus will infect the cells and can be detected using a BVD-specific antibody. BVD-ELISA positive animals should be retested 4 weeks later to determine true persistent infection as opposed to acute

infection.

PREVENTION AND CONTROL OF BVD IN BEEF HERDS

If your herd is free of BVD-infection, several precautions should be taken to keep this status. To prevent the introduction of BVD viruses, all replacement heifers and bulls need to be tested for BVD virus. Although bred heifers may be negative, they may still introduce BVD into a herd in the form of PI calves. Where possible, bred heifers should be purchased from BVD-tested herds. Replacement heifers should be calved and summered separately from the cow herd to avoid infection should they give birth to a PI calf. Open cows and heifers should be strictly culled. Neighboring herds or herds that share pasture should be encouraged to use the same vaccination schedule and biosecurity measures. BVD prevention is only effective if producers work together.

If your veterinarian makes a diagnosis of BVD in your herd, then eliminating the virus should be a priority. Endemic BVD will reduce the % of weaned calves by as much as 30%. The herd should be screened for PIs starting with all replacement yearling and two year old heifers. When identified, the PIs should be culled and their dams identified and tested. Strict culling of open cows at fall pregnancy check and calving will also help to eliminate potential carriers. If steer calves are retained, they should either be tested or pastured separately from any pregnant heifers or cows. The preventive measures are aimed at breaking the cycle of fetal infection. Ideally, testing should occur before breeding to prevent intermingling of PI calves with pregnant dams. Maternal antibodies interfere with most screening tests in calves under 3 months of age. If breeding cannot be delayed, then the calves should be screened at weaning. Producers should be prepared to test and remove PIs over a 2 to 3 year period in order to eliminate BVD.

To prevent severe disease due to acute BVD infection and to reduce the spread of BVD through the herd, modified live (MLV)-BVD vaccines should be given to all cows at branding. High maternal antibodies will be passed to the calf in colostrum and provide some protection against acute BVD infections. These same maternal antibodies will neutralize BVD antigens present in vaccines. Therefore, calves should be vaccinated after weaning (when maternal antibodies have declined) for the vaccines to be effective. Replacement heifers should receive a minimum of two vaccinations with MLV BVD vaccine, one month apart, and the booster given 45 days before breeding.

Vaccination will not prevent fetal infections if the cows become infected with BVD viruses that are antigenically different from the vaccine virus or if the cows are exposed to large amounts of virus shed by a PI animal. The variability of BVD viruses means that producers cannot depend solely on vaccination to prevent BVD from entering their herds. There are no BVD vaccines available that will substitute for good biosecurity measures. By increasing herd immunity and reducing the risk of exposure to BVD, producers can avoid BVD infection and associated diseases.

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