Effectiveness of Vaccination Programs in Replacement Heifers

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Take Home Message

- Vaccinating dairy heifers serves two purposes:
  - Protecting the heifer from infectious disease as she grows
  - Preparing the heifer's immune system so that it will provide protection to the fetus during the heifer's first pregnancy
- Vaccines are not a replacement for other management tools such as colostrum management, nutrition, hygiene, ventilation, housing and biosecurity
- It is essential that all calves receive 4 litres of good quality colostrum within the first 6 hours of life
- Modified live vaccines tend to provide better and longer lasting immunity than killed vaccines
- Recent research would suggest that calves as young as two to four weeks of age can effectively respond to vaccines even in the face of maternal immunity
- Clostridial vaccines should be a standard part of any replacement heifer vaccination protocol
- A modified live prebreeding vaccination for IBR, BVD, BRSV and PI3 viruses is the backbone of a heifer vaccination program
- Work with your veterinarian to develop a risk based vaccination protocol tailored to the needs of your dairy operation

Introduction:

Raising dairy heifers represents a significant economic cost to the dairy enterprise. The cost of raising replacements is often considered the third

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highest expense of dairy operations after feed and labor costs. It certainly makes sense to try to protect this investment and an effective vaccination program is an essential component of a risk mitigation program. However, it should be noted that vaccines are not a silver bullet and many other factors such as nutrition, maternity pen management, hygiene, colostrum management, biosecurity, and calf housing and ventilation are essential parts of an efficient replacement heifer rearing program. Vaccines cannot do their job in the face of significant management deficiencies in any of these areas. Vaccination programs should be developed in consultation with your local veterinarian who understands your herd and your management style. Vaccine protocols are not a "one size fits all" program and need to be developed based on the risks associated with your particular heifer rearing operation. The timing of vaccination and the products used may vary significantly between farms depending on the level of risk that the calves will face based on the other management factors on the farm. The goal of the vaccination program is to provide immunological protection for the heifer in two very specific areas:

- To protect the young calf from specific diseases that may affect it as it grows such as pneumonia or clostridial diseases.
- To protect the fetus of the heifer in her first pregnancy from infectious agents that can cause fetal loss, abortion or other diseases.

Immunology 101

Some Immunological Terms

In order to understand when and how vaccines should be used, it is important to have a basic understanding of how the calf's immune system functions. The development of the immune system in calves progresses in small steps, beginning at conception and reaching maturity with a functional immune system at approximately 6 months of age (Chase et al, 2008).

Immunology is a very complex science and this review will only give the basics of the function of the immune system. However, it is important to understand a few basic definitions in order to appreciate the development of immunity. An antigen is a substance which when introduced into the tissues of an animal stimulates the immune system to produce antibodies. Antigens can be bacteria, viruses, toxins or parasites and all will induce an immune response in healthy animals.

Antibodies are blood proteins which are produced as a result of the introduction of an antigen. Antibodies (or immunoglobulins) are produced by white blood cells in the blood and at some body surfaces. They are produced

in response to particular antigens and bind with those antigens helping to destroy the foreign invaders. This type of immunity is known as humoral immunity.

Another part of the immune system is known as cell-mediated immunity and this involves stimulation and activity of a wide range of cells in the immune system. Cell mediated immunity is extremely complex and is beyond the scope of this discussion, but is an important component of the immune system alongside humoral immunity (antibody response).

Active versus Passive Immunity

Two forms of antibody responses are recognized. Active immunity is when a calf actively produces its own antibodies as a result of being exposed to an antigen. This antigen exposure may be in the form of a vaccine or it may be because of a natural infection. Active immunity takes time to develop and there is a latent period after an antigen is introduced before antibodies can be detected. It usually takes two to three weeks for antibodies to peak after a vaccine is given or after an infection with a virus or bacteria occurs. If however, the same antigen (virus or bacteria) is reintroduced once a primary antibody response has occurred, there is a much shorter lag phase and a much more rapid response in the production of antibodies. The immune system has a “memory” and will have a much faster production of antibodies if it has been previously exposed to the same antigen. This is known as an anamnestic or memory response. Active immunity takes longer to develop but it is relatively long lasting.

Passive immunity is when antibodies are transferred from one animal to another. In the dairy calf, passive immunity is transferred from the dam to the calf when the calf consumes colostrum. Pregnant cows will have antibodies circulating in their blood which would help to protect their unborn calves from a wide range of diseases. An important component of a vaccination program is to provide vaccines to the cow prior to breeding so that the fetus is protected from a number of diseases throughout the gestation period. The structure of the placenta is such that antibodies can’t pass from the circulation of the cow to that of the calf. Therefore, the calf is born without any circulating antibodies.

Nature has overcome this impediment by first, ensuring that the colostrum of the cow is rich in antibodies; and secondly, by insuring that the intestine of the calf is able to absorb these large proteins into the bloodstream. However, this absorptive capacity deteriorates very rapidly so that by as early as six hours after birth, a significant decrease in the ability to absorb antibodies begins to occur. The intestines continue to gradually lose this absorptive ability so that by 24 hours, antibodies can no longer be absorbed into the calf’s bloodstream.

To achieve successful passive transfer of antibodies in an average 43 kg Holstein calf, experts calculate that producers should feed a minimum of 4 litres of colostrum at the first feeding. Producers should aim to feed all calves within 1-2 hours after birth and by 6 hours at a maximum (Godden, 2008). Achieving early and adequate intake of high-quality colostrum is widely recognized as the single most important management factor in determining the health and survival of the neonatal calf (McGuirk, 2007).

Active Immunity in Calves and Maternal Interference

It is important to recognize that although the immune system is complete at birth, many of the components of the system are not completely functional until calves are at least 2-4 weeks of age (Chase, 2008). For a few days before and after birth, the immune responses of the calf are suppressed because of maternal and fetal steroid production. However, the newborn calf does have a functional yet naïve immune system although it needs some time to develop a mature response (Woolums, 2007).

For many years, veterinarians believed that young calves with passively acquired antibodies (via colostrum) circulating in their bloodstream could not be effectively vaccinated. It was assumed that the passively acquired "maternal immunity" would interfere with the normal antibody response. It was previously thought that vaccines could not be given effectively until the maternal antibody waned to a low enough level which could be anywhere from a few weeks to 8 months of age (Chase, 2008).

However, recent research has shown that young calves vaccinated in the face of maternal immunity will show evidence of cell mediated immunity and even will display a memory response of antibodies for protection when exposed to the same antigen later in life (Woolums, 2007)

■ Killed versus Modified Live Vaccines

Vaccines can be divided into two basic types: killed and modified live vaccines. In killed vaccines, the viruses or bacteria that make up the vaccine have been made non-viable so that they will stimulate an immune response but they cannot cause disease. Many modern vaccines only use specific proteins of the disease-causing agent rather than the entire bacteria in order to stimulate a very specific immune response. Killed vaccines can be used safely in pregnant cows and usually do not require on-farm mixing. They tend to be more stable in storage. However they often require two initial doses and may not produce as strong or lasting immunity.

The modified live vaccines have living viruses in them that can multiply and proliferate in the animal thus stimulating an even stronger immune response

in most cases. The viruses have been modified so as not to cause disease, however, direct exposure of the fetus to modified live vaccines in a pregnant cow can potentially cause abortion. Live vaccines give more rapid protection even with only one dose and usually induce higher levels of immunity. However, they often require more careful handling and mixing on farm and are less stable once mixed. They may induce abortion or fetal loss if used in pregnant cows except under very special circumstances.

■ Goals of a Vaccination Program for Replacement Heifers

Vaccines are available for a number of important infectious diseases of dairy calves. However, it is important to understand that no vaccine provides absolute or complete protection. Vaccines if used appropriately will help to increase the immunity in the herd and the resistance to disease in individuals. They will not make up for significant deficiencies in calf rearing management.

As stated earlier, we have two major goals that we wish to accomplish with our vaccine program:

- To protect the young calf from specific diseases that may affect it as it grows such as pneumonia or clostridial diseases.
- To protect the fetus of the heifer in her first pregnancy from infectious agents such as BVD virus that can cause fetal loss, abortion or other diseases.

■ Clostridial Diseases

Clostridia bacteria cause acute and often fatal disease in young growing calves. The bacteria are common in the soil and manure in the environment and hence calves are constantly exposed to them. These bacteria are spore formers and can survive in the environment for long periods of time. Blackleg is the most common form of clostridial disease that is seen in young unvaccinated calves. It can cause sudden death as it creates a severe infection of the muscle tissue of the calf. Vaccination for clostridial diseases is routinely recommended in all young ruminants and although there are very few clinical studies on the effectiveness of the vaccine, the long term use of clostridial vaccines in both the dairy and beef industry would suggest that it is a highly effective vaccine.

■ Calf Pneumonia

Dairy calf pneumonia is a multifactorial disease that is caused by a variety of disease causing agents, calf factors and environmental factors. Some of the viruses that have been implicated include bovine respiratory syncytial virus (BRSV), parainfluenza-3 virus (PI3), infectious bovine rhinotracheitis virus (IBR virus) and bovine viral diarrhea virus (BVDV). Bacterial agents such as *Histophilus somni, Mannheimia hemolytica, and Pasteurella multocida* are also often involved. Vaccines are available for all of these various disease causing agents and many vaccine companies have combination vaccines that at least include the four viral agents and sometimes some of the bacterial pathogens as well.

Dairy calves can be affected with pneumonia between 2 and 6 months of age with a peak incidence occurring at 5-6 weeks of age (Ames, 1997). Van Donkersgoed showed that the risk of pneumonia was 29% in Saskatchewan dairy calves (Van Donkersgoed, 1993). Other studies from Canada and the U.S. show rates of disease at 7.4% - 15% (Ames, 1997). Case fatality rates for calves with dairy calf pneumonia range from 2.2% - 9.4%.

Major environmental risk factors for calf pneumonia include housing calves with adults, poor ventilation, crowding, and cold, wet weather conditions. Outdoor hutches were superior to all other methods of calf raising as a means of preventing calf pneumonia (Ames, 1997).

Calf level risk factors include dystocia, poor maternal transfer of immunity, being born to a first calf heifer and pail feeding colostrum. Almost all of these calf level risk factors can be controlled by ensuring that high quality colostrum is fed to calves appropriately within 6 hours of birth.

Vaccinating for Dairy Calf Pneumonia

Designing a vaccine program to aid in the prevention of dairy calf pneumonia is a risk based process. Dairy producers who utilize outdoor hutches and have good colostral management will have very low level of risk for dairy calf pneumonia. Producers with this type of low risk situation might utilize viral vaccines in their young calves primarily in order to prepare their immune system to protect the fetus in their first pregnancy. Conversely, dairy producers who experience higher levels of calf pneumonia because of poor ventilation or group housing might consider a more aggressive vaccine protocol which would utilize both the viral vaccines as well as some of the bacterial vaccines such as *Mannheimia hemolytica* and *Histophilus somni*. It is important to utilize your local veterinarian to plan an appropriate risk-based vaccination protocol for your heifer calves.

Well designed field trials are the best way to evaluate any vaccine or therapy.

Unfortunately good field trials for vaccines are expensive and logistically difficult to perform. There are relatively few conclusive field trials to help us to determine the efficacy of the various respiratory vaccines for young dairy calves. Aubry et al (2001) reported that Holstein dairy calves between 14 and 20 days of age that were vaccinated twice with a Mannheimia hemolytica and Pasteurella multocida vaccine had no significant benefits in health or growth performance. A field trial in beef calves vaccinated with a modified live BRSV vaccine and a Mannheimia hemolytica leukotoxin and Histophilus somni vaccine showed that calves that received the vaccine (in the face of maternal immunity) had lower treatment rates (15%) than calves that did not receive the vaccine (34%) (Van Donkersgoed et al, 1994).

In many cases, we are forced to rely on experimental studies in which there is now a significant body of work that would show that many of these modified live vaccines are protective and produce immunity in young calves that are vaccinated in the face of maternal immunity. This protection in young calves may require two doses especially if the first modified live vaccine is given at less than 4 weeks of age (Woolums, 2007).

■ Preparing the Heifer's Immune System for Her First Pregnancy

An absolutely essential aspect of every vaccination program in dairy heifers is to prepare the heifer's immune system so that the fetus will be protected in her first pregnancy. IBR virus and BVD virus can both infect the fetus and cause abortion or other diseases. If BVD virus infects an unvaccinated pregnant heifer the virus can cause a number of consequences depending on the timing of the infection. The virus targets the fetus and can cause early embryonic death, abortion or congenital defects. If the fetus is infected between 42 and 125 days of gestation, the fetus can become persistently infected with BVD virus. These calves can survive to term and be born alive and thrive normally or can be unthrifty. These persistently infected calves are the main reservoir of the virus in the population and continuously shed high quantities of virus. BVD virus can cause immunosuppressive effects in calves that become infected by being in contact with a persistently infected calf and can predispose the calf to other diseases such as calf scours or calf pneumonia.

There has been a great deal of recent research examining whether or not BVD vaccines are effective at protecting the fetus from fetal infections with BVD virus. Modified live vaccines given pre-breeding to cattle typically provide protection to the fetus in the range of 80% or greater. Killed vaccines are usually less effective at providing fetal protection (Grooms, 2008).

BVD virus is one of the most economically important infectious agents of dairy cattle. All vaccination programs should set up dairy heifers so that they will be adequately protected against BVD virus when they reach breeding age. This requires a prebreeding vaccination at 12-13 months of age with a modified live vaccine containing IBR, BRSV, PI3 and BVD virus. Ideally at least one and perhaps two previous vaccinations would be given typically at 4 weeks and 6 months of age in order to maximize immunity and provide some protection against respiratory disease as well. Clostridial vaccines would typically be given at these time periods as well.

Summary

It is important that the dairy producer and veterinarian develop a vaccination program that is tailored to meet the risks associated with the management of the operation. Every vaccination program will have the ultimate goal of providing protection to the heifer during her first pregnancy so that the fetus is protected against IBR virus and BVD virus. Good colostrum management, hygiene, nutrition, ventilation, housing and biosecurity are absolutely essential factors in preventing disease in replacement heifers and getting the calf off to a good start. Vaccines are an important adjunct to these management tools in preventing respiratory disease in the young calf but are not a replacement for good management.

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