The Role of Vaccination in a Good Herd Health Program

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Take Home Messages

- Routine vaccination is an integral part of an effective herd health and biosecurity program
- Immunity is a complex interaction between non-specific and specific host defense mechanisms
- Vaccination is impacted by genetics, age, nutrition, and physiological status of the cow or calf
- "Vaccine failure" is most often associated with a faulty vaccination program rather than a faulty vaccine
- *Vaccination is a management tool, not a "silver bullet"!*

Introduction

Vaccination has been with us for about 200 years. Although it is relatively simple procedure, it is probably the single procedure that has saved more human and animal lives than any other. Due to the effectiveness of vaccines in reducing or eradicating many important diseases in human and veterinary medicine, many are now questioning the necessity of routine vaccination for human and animal patients. One merely needs to travel to parts of the world that do not use vaccines, to see the fallacy in this thinking.

With globalization and increased international trade in animals and animal products, herd health and biosecurity to further reduce transmissible infectious diseases will become increasingly important to maintain markets. Biosecurity or procedures to control the exposure of cattle to various bugs or pathogens is well established in poultry and swine production, but is underutilized in most

cattle operations. Routine vaccination is an important management tool in maintaining herd health and biosecurity in a dairy herd.

▪ Immunity to Disease is the Result of Complex Interactions

Cattle and other mammals have developed both specific and non specific immune mechanisms to defend themselves from invasion by microbes, the viruses and bacteria that cause disease. As a first line of defense, non specific immune mechanisms include such things as physical barriers to invasion and cells that eat or phagocytize foreign invaders if they breach the physical barrier. The skin is the body's largest organ and most obvious barrier to invasion. However other body surfaces, such as the respiratory, gastrointestinal, and urogenital tracts also have physical defenses or "self cleaning" processes that defend against invasion, including, sneezing, coughing, and mucous and urine flow. Vomiting and diarrhea are more dramatic ways in which most mammals can rid their systems of unwanted microbes. As well, there is colonization of all these body surfaces with normal harmless flora or bugs that compete with more nasty invading microbes.

If a bacteria or virus should breach the physical barriers and invade the body, a second line of defense, called inflammation, comes into play. White blood cells called neutrophils and monocytes non-specifically attack, eat and digest invaders. This activity is an especially important non-specific defense against bacterial invaders, whether they enter through the mouth, nose or teat. Another component of inflammation is an enzyme system, called complement, which can break down microbes.

If a bacteria or virus should survive, the first and second lines of defense, and persist, specific immune responses come into play. This is the part of the overall immune response that can be enhanced by vaccination. For specific immune responses to occur, cells called macrophages or antigen presenting cells act as scavengers that pick up bacteria or viruses or vaccine components and process them and transport them to small organs called lymph nodes that are strategically placed around the body. Here these cells "present" the bits of microbes, called antigens to other cells called lymphocytes, that are the main players in specific immune responses. The spleen is the major internal organ in which immune responses occur. Specific soluble factors and cells that emanate from these or organs disseminate to all parts of the body to fight off an infection. There are two major components of specific immunity, soluble factors called antibodies that are produced by cells called B lymphocytes, and specialized cells that destroy infected or damaged cells in the body, called T lymphocytes. These antibodies and lymphocytes are designed to recognize and interact with the bacterial and viral antigens that were presented to them by macrophages. After the first exposure to a virus or bacteria either through

natural infection or vaccination, a weak immune response is generated. Upon repeated exposure to the same bacterial or viral antigens, the specific immune responses become stronger. That is why it is important to give booster vaccinations, to achieve the best protective immune responses.

There is both "active" and "passive" specific immunity. "Active" immunity occurs in response to an infection or vaccine. "Passive" immunity is immunity that is passed from the cow to the calf. Cattle, and in fact most domestic animal species are very different than human beings when it comes to passive immunity. Human babies are usually born with protection from the microbes that their mother has been exposed to since protective antibodies are transported across the placenta to the developing fetus. In contrast, calves are born completely unprotected or immunodeficient because antibodies do not cross the placenta in ruminants. This is why it is critical that calves receive the first milk or colostrum as soon as possible after birth. Calves that do not receive colostrum within the first 18 invariably die from bacterial and viral infections.

▪ "Cow Factors" that Effect the Response to Vaccines

There are many different types of vaccines on the market today and more are under development. Suppose a perfect vaccine could be developed that contained all the bugs or pathogens that are known to cause disease in cattle, and that this vaccine could be delivered safely and cheaply to all of the cattle on earth. Could we eliminate infectious disease in cattle? Probably not because even if a good vaccine is administered properly there are several, often overlooked "cow factors" that impact on vaccine efficacy.

Genetics

Compared to their ancestors, today's cattle breeds are highly inbred. Most cattle have been highly selected for various production traits, without much thought for how these selection pressures have effected the natural ability to generate immune responses. The impact of genetics of immune responses to various pathogens is recognized, but currently poorly understood in cattle.

Age

The age of an animal can also effect the response to vaccination. Very young and very old animals tend to have less effective immune responses to naturally acquired infections and vaccines. As well, passively acquired maternal or colostral antibodies can effect the response to vaccines.

Nutrition

In order for cattle to respond to vaccination and fight off infections, adequate nutrition is necessary. Adequate energy, vitamins, minerals, as well as adequate clean water is required, not only for optimal production, but also for maintaining protective immune responses. We are just beginning to fully understand the important role of various micronutrients such as zinc in the immune response. Even the perfect vaccine will not be effective in a malnourished cow.

Physiological status

In addition to maintaining an adequate plane of nutrition, the cows' physiological status is also a very important determinant in response to vaccines. Stressors such as transport, crowding and extremes in environmental temperatures are known to have a negative impact on the immune response. As well, pregnancy is a time of relative immunosuppression in cattle. Lactation also puts a unique physiological stress on high producing dairy cattle that can negatively impact on the response to vaccination. Failure to appreciate these and other physiological factors in the timing of vaccination will result in a less than optimal response to even a perfect vaccine.

▪ Why Vaccines Fail

Vaccines that are on the market today have passed federal regulatory tests and are generally safe and effective if given as directed. However many producers have experienced instances when vaccines have apparently "failed" to protect. Many things may account for apparent "vaccine failure" when a perfectly good vaccine has been used.

If a vaccine is correctly administered and the animal responds to the vaccine, there are at least 2 factors that may account for apparent "vaccine failure":

- vaccine was given too late; animal was already infected
- wrong microbe or strain used; animal has disease caused by microbe other than is in the vaccine

If a vaccine is correctly administered and the animal fails to respond, there are several factors that may account for apparent "vaccine failure":

- vaccination of young calves with high maternal antibodies may be ineffective
- the animal may be "immunosuppressed"
- the animal may be a poor responder to the vaccine

Several factors may relate to incorrect administration that makes a vaccine appear to “fail”

- failure in delivery; “the one that got away”
- inappropriate route of administration
- death of microbe in modified-live vaccine
- administration of vaccine to a calf with high maternal antibodies

▪ Vaccination is a Management Tool not a Panacea

Vaccination is only one tool in an overall management plan to maintain herd health. Primary vaccinations and boosters must be given in timely fashion to healthy-well nourished animals to generate effective immune responses. The overall goal of vaccine usage should be to maintain a preventative, protective level of “herd immunity” rather than a stop gap method, or a select procedure used only in a segment of the herd. Timely vaccination should also be used to bolster passive immunity in young calves, again by routine vaccination of the cow herd. This is especially important in first calf heifers that tend to have poor quality colostrum. Vaccines can also be administered to young calves in situations where there is a high level of microbial challenge, or when the immune status of dams is unknown. Vaccination alone usually cannot eliminate disease from a herd. Careful consideration should be given to other means of maintaining biosecurity, such as testing and quarantine of replacement heifers and other new breeding stock. In short, vaccination is not a replacement for good management

▪ Reference

1. Tizard, I.R. 1997. Veterinary Immunology: An Introduction. 5th edition. W. B. Saunders, Philadelphia.