COLLEGE OF AGRICULTURAL, CONSUMER AND ENVIRONMENTAL SCIENCES

Cattle Vaccination and Immunity

Revised by John Wenzel[1]

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VACCINATION AND HERD HEALTH

Developing immunity in cattle requires an effective herd health program. Vaccinations are not a silver bullet cure-all for disease in a cow herd, but they are a primary component of a complete herd health program. Vaccines contain **antigens** of disease-causing agents, either viral or bacterial, and are used to stimulate cattle's immune systems and create an immune response before cattle have had significant natural exposure to disease-causing agents. It is important to understand that vaccination does not equal immunization. Many factors influence the immune response to vaccinations, including stress, vitamin and mineral balance, nutrition, how the immune response was "primed" early in the animal's life, the colostral immunity the newborn calf received, and overall health of the animal being vaccinated. A basic understanding of how the immune system responds to a vaccine is important for understanding how vaccines function.

The first time a calf's immune system encounters a **pathogen**, it often cannot respond quickly enough to prevent disease in a naturally occurring exposure. In most cases, however, the immune system usually succeeds in neutralizing the infection over time. If the antigen exposure is from an initial or "priming" vaccination that contains **modified-live virus** (MLV) or **chemically altered** (CA) components, then an immune response called

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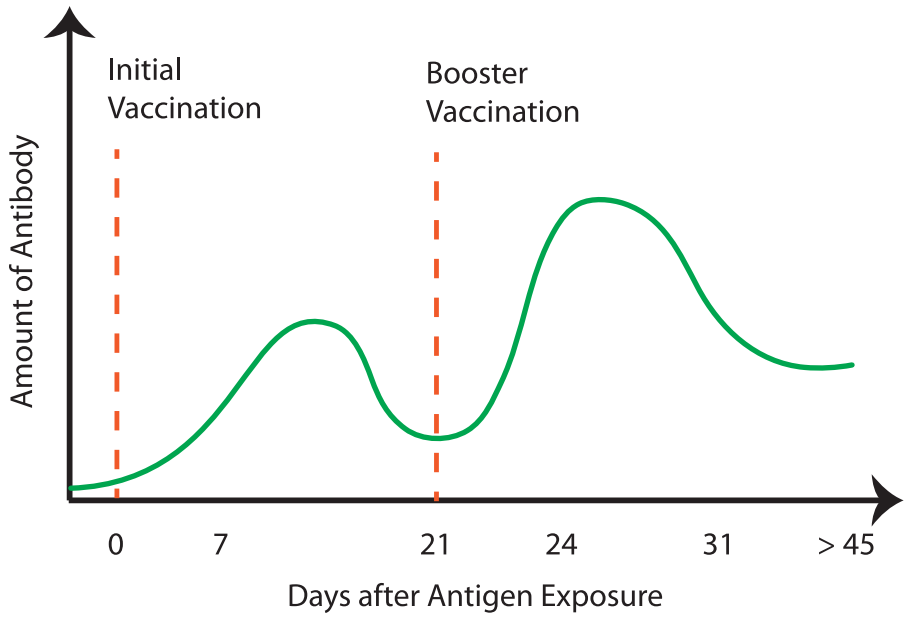

Figure 1. **Change in serum antibody concentration over time after a primary and secondary (booster) exposure to vaccine antigen.**

cell-mediated immunity (CMI) would be triggered. This CMI response, once activated or "primed," will be the most effective and robust immune response the animal can mount whenever a viral exposure takes place. This CMI response requires the vaccine component to "replicate" (reproduce) inside the animal's tissue, and this replication is what activate or "primes" the CMI response. **Killed vaccines** are incapable of replicating and therefore cannot "prime" the CMI response. If the immune system has been primed with either MLV or CA vaccines, the response to killed vaccines may be enhanced because of the CMI response.

After an animal recovers from a natural infection, or has been vaccinated, memory cells that have been produced by the immune system remain for months to years. Memory cells are programmed to recognize specific pathogens if they are encountered again, and facilitate a response before the pathogen can cause disease. Memory cells recognize parts of a pathogen's body called antigens. Antigens are molecules unique to each pathogen, and memory cells use these antigens to recognize specific pathogens. Vaccines work by exposing the immune system to antigens from a specific pathogen, tricking the body into thinking is has encountered the actual disease causing agent. Exposure to an antigen in a vaccine stimulates an immune response, which creates memory cells for that pathogen without causing the negative effects of an actual first infection.

Most viral vaccines contain components consisting of modified-live virus, chemically altered virus, or killed virus. Some vaccines may have a combination of viral types. The MLV and CA components contain live virus particles that can replicate but have been modified or altered so that they have the antigenic components of the disease-causing agent but do not cause disease, whereas killed vaccines contain antigen components or pieces of the disease-causing agent. Presenting the antigens to the immune system for processing greatly depends on the type of vaccine used and on the route of administration. For example, an MLV vaccine labeled for **intramuscular injection** may not yield the desired immune response if it is instead administered **subcutaneously** because the viral replication that follows may not fit how the vaccine was developed and tested.

Secondary exposure to a pathogen, or a second (booster) vaccination of either viral or bacterial antigens, makes the immune system stronger and better prepared for future exposure to the disease pathogens contained in the vaccine. A **booster vaccination** creates a faster, stronger immune response (called an anamnestic immune response) of longer duration because the concentration of memory cells and the cells necessary to mount a quick immune response have already been primed and are ready for activation. The effectiveness of this response will increase with repeated exposure to an antigen (Figure 1). This is why one vaccination usually does not provide sufficient protection. Most vaccines require at least one booster vaccination two to four weeks after the initial vaccination (although some protocols will require more than one booster), and annually thereafter. The goal is to stimulate the immune system by repeated exposure to an antigen so memory and other immune cells are present in the body at a level that is highly protective if exposure to the actual pathogen occurs. However, disease may still occur in cases where pathogen exposure exceeds the animal's protective level for that disease.

WHY VACCINATED ANIMALS STILL SOMETIMES GET SICK

The most common reason vaccinated animals get sick is because they fail to fully respond to vaccination, or fail to become immunized. Procedures to maximize immune response include following label directions for timing, route of administration, and proper vaccine handling, and minimizing stress that can suppress immune function. How and when the dam is vaccinated directly influences her ability to produce a better-quality colostrum, which can influence the calf's ability to fully activate and utilize the entire immune response for the rest of its life. All vaccines, especially MLV and CA vaccines, must be handled very carefully. Exposure to heat or sunlight or being mixed too long prior to use can reduce a vaccine's effectiveness. All vaccines must be kept cool, even while the vaccine is in the syringe. Nevertheless, even when everything is done correctly, some animals fail to mount an immune response sufficient to create immunity to the disease. Factors contributing to this failure are stress, poor nutrition (including micro and macro mineral imbalance or deficiency), vitamin deficiency, **congenital immunodeficiency**, inadequate colostral immunity received, and poor overall health.

While it does not provide perfect protection, vaccination is the most effective tool available to prepare an animal's immune system to respond to disease challenges. Preparing the immune response before exposure to stress and disease will result in cattle being better able to mount an adequate immune response when challenged. A sound vaccination program developed with your veterinarian and carried out using proper timing and technique is critically important for maintaining the health and profitability of your herd.

GLOSSARY

Antigens: Molecules unique to each pathogen by which the immune system recognizes the pathogen.

Booster vaccination: Second vaccination to stimulate an enhanced immune response via repeated exposure to an antigen.

Chemically altered (CA): Viral vaccine that contains live virus components that have been altered in such a way that the virus will replicate in the body, but replication stops once the virus reaches body temperature (temperature-sensitive virus) so it cannot cause disease.

Congenital immunodeficiency: Weakness of the immune system present at birth.

Intramuscular injection: Injection directly into muscle tissue.

Killed vaccines: Vaccines containing antigen (viral or bacterial) components or pieces of the disease-causing agent that cannot replicate or cause disease.

Modified-live virus (MLV): Vaccines containing live virus components that have been modified so that the virus will replicate inside the animal's body but will not cause the clinical disease.

Pathogen: Disease-causing agent.

Primary vaccination: The initial exposure to an antigen via vaccination.

Subcutaneous injection: Injection into the fatty layer of tissue immediately beneath the skin.

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