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G02-1445 Understanding Vaccines

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Understanding Vaccines

This NebGuide explains the basics of vaccine value, the differences between types of vaccines used in animals, and discusses vaccine selection and vaccination program development.

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Vaccines are an important part of disease prevention and control. Like insurance, vaccines come at a cost, including the price of the vaccine, labor to administer the vaccine, localized tissue damage from vaccine injections, and increased metabolic demand of the animal causing potential performance loss during the time the animal is developing a proper immune response. The increased metabolic demand can cause the animal to look depressed and therefore may be confused with illness. This is sometimes referred to as "vaccine sweat." If the risk of a particular disease is low, the insurance afforded by vaccination may not be required and the benefit provided might not be cost effective. If the risk of disease is high, the insurance afforded by vaccination may be very cost effective even if it does not completely prevent sickness. It is important to view vaccines only as an aid to health management and not the foundation of animal health.

Vaccine Terms

Vaccine: A preparation of a weakened or killed pathogen, such as a bacterium or virus, or of a portion of the pathogen's structure that upon administration stimulates antibody production against the pathogen but is incapable of causing severe infection.

Antigen: A substance that when introduced into the body stimulates the production of an antibody.

Antibody: A specific disease protection protein produced by the animal's body in response to contact with disease causing organisms or vaccine.

Adjuvant: An immunological agent that enhances the immune response to a vaccine.

Endotoxin: A bacterial cell wall component released when bacteria die that is able to cause collapse of several animal physiologic processes (Endotoxic Shock). Endotoxin can be a problem in poorly manufactured killed bacterial vaccines or when multiple bacterial vaccines are given at once. Frequently the endotoxin level in autogenous bacterial vaccines is high and therefore should be used with caution. Ask your veterinarian for more information on this subject.

Interferon: A protein produced by cells in response to infection by a virus that acts to prevent viral replication and have the ability to induce resistance to viral antigens.

Active immunity: Immunity produced in response to a disease organism or vaccine.

Passive immunity: Immunity, usually antibodies, acquired from colostrum or anti-toxins. Although duration of activity is brief (weeks to months), it is critical to the health of young animals. While present, passive immunity may interfere with the immune response to a vaccine. Colostrum provided to infants is the most common example of acquired passive immunity.

Intramuscular (IM) Injection: An injection given in the muscle. The size (length and diameter) of the needle used should be appropriate for the animal.

Subcutaneous (SQ) Injection: An injection given between the skin and underlying muscle. SQ is the preferred route of administration for all vaccines given to food producing animals because of the damage done by IM injections to edible tissue. This is especially true of killed vaccines that contain an adjuvant such as aluminum hydroxide or oil. Because SQ injections cause less damage to muscle, it is reasonable to think SQ administration is more humane and could improve animal performance.

Intranasal (IN) Administration: Aerosolized product delivered through the nasal cavity.

Vaccine Types *(Figure 1)*

Killed vaccines (KV) and toxoids are killed microorganisms, organism components or organism by-products. KV products use a large amount of organisms and adjuvants such as aluminum hydroxide or oil to produce a sufficient immune response. Adjuvants enhance the immune response by increasing the stability of the vaccine in the body, which then stimulates the immune system for a longer time. The major advantages of killed vaccines are safety and stability of the product.

Subunit vaccines are a type of killed vaccine that contains only part of the virus or other microorganism. These vaccines were developed to either isolate or engineer the most important part of the microorganism needed to produce a proper immune response and eliminate the part(s) of the microorganism that caused adverse vaccine reactions or interfered with a proper immune response.

Autogenous bacterial vaccines (Autogenous Bacterins) are produced from disease causing organisms isolated from sick animals. The disease causing bacteria are grown in culture, killed and mixed with an adjuvant. These vaccines frequently contain high levels of endotoxin and other by-products found in the culture (debris). Because autogenous vaccines frequently contain high levels of endotoxin and other by-products found in the culture (debris), they should be used with caution.

Modified live vaccines (MLV) contain a small quantity of virus or bacteria that has been altered so that it no longer is capable of causing clinical disease but is still capable of infection and multiplying in the

animal. Recognition of the replicating organism by the animal's immune system results in an enhanced immune response. The immunity produced by MLV typically lasts longer than the immunity produced by killed vaccines. Handling and storage of MLV products is critical. Exposure to high temperatures, sunlight, freezing temperatures, disinfectants or soaps can damage or destroy a MLV product. MLV products require rehydration of lyophilized vaccine cake with provided diluent and should be used within an hour of mixing. The major advantage of modified live vaccines is a broader scope and duration of protection because the animal is exposed to all stages of the replicating virus or bacteria.

Chemically altered vaccines contain modified live organisms that have been grown in a media containing adjusted levels of certain chemicals that trigger and amplify mutation of the organism, changing the organism's metabolism in such a way as to alter the ability to cause disease. Temperature sensitive (TS) vaccine organisms are examples of an organism produced by this process. The TS organism loses the ability to grow at the animal's normal body temperature but can grow at the temperatures present in ocular or nasal mucosa. Chemically altered organisms are considered safer than typical modified live organisms, but when given by a route other than direct contact with the mucus membranes stimulate little or no local immunity. The immune response produced is similar to MLV products but the duration of immunity is not considered to be as long. The major advantage of chemically altered vaccines is they are safe to use with pregnant animals because there is no systemic replication of the vaccine organism.

Figure 1. Vaccine types: advantages vs disadvantages.

Killed Vaccines (KV) and Toxoids

Advantages:

- Available for a wide variety of diseases
- No risk of reverting to virulent form
- No risk of vaccine organism spreading between animals
- Little risk of causing abortion
- More stable in storage
- No on-farm mixing, therefore less risk of contamination
- Excellent stimulant of passive antibodies in colostrum

Disadvantages:

- More likely to cause allergic reactions and post vaccination lumps
- Two initial doses required at least 10 days apart
- Slower onset of immunity
- May not produce as strong or as long-lasting immunity as MLV products
- Produce a narrower spectrum of protection than MLV products
- Tend to be more expensive than MLV products

Modified Live Vaccines (MLV)

Advantages:

- One initial dose is usually sufficient but additional booster doses may be required
- More rapid protection than KV products
- Produces a wider spectrum of protection than KV products
- Less likely to cause allergic reactions or post vaccination lumps than KV products
- Less susceptible to passive antibody vaccine block than KV products
- Tend to be less expensive

Disadvantages:

- Potential to mutate to a virulent form
- Could exacerbate disease in immunosuppressed animals
- Potential for excessive immune response
- Some risk of causing abortion or transient infertility
- Must be handled and mixed with additional care

Chemically Altered Vaccines

Advantages:	**Disadvantages:**
• Share many characteristics of MLV products • Safety similar to KV products • More rapid protection than KV products • No risk of reverting to virulent form • Little risk of causing abortion	• Protection not as rapid as MLV products • Two initial doses required • May not produce as strong or as long-lasting immunity • Unless given on a mucus membrane, stimulates little or no mucosal immunity • Must be handled and mixed more carefully • Tend to be more expensive than modified live vaccines

Note: Vaccines generally are not as effective when given in the presence of passive colostrum immunity and therefore in general, animals younger than three months of age should be revaccinated. Visit with your veterinarian about specific questions relating to vaccination timing.

What Should Be Expected From Vaccines

Vaccines should stimulate the immune system similar to a natural infection. Vaccines may not be able to completely prevent a natural infection but the vaccine should reduce the severity or limit the frequency of the disease. This is especially true of many bacterial diseases such as those that cause respiratory or intestinal disease. Immunity produced by a vaccine should last long enough to protect the animal through the typical time the animal will be exposed to the natural disease. For instance, a vaccine used to protect an animal from a reproductive disease may not need to protect the animal longer than the typical breeding season. Vaccines should have minimal side effects and if side effects are present, they must be acceptable. An example of an unacceptable side effect of vaccine is the potential for abortion when used on or in association with pregnant animals.

Lastly, the cost of vaccination should be less than the economic loss incurred by the naturally occurring disease. The cost of vaccination should consider the long-term effects of the disease and long-term economic losses. Vaccines should not be expected to eliminate all disease problems. Many additional management procedures such as animal density, nutrition, environmental control, movement of animals, levels of stress, cleanliness of the environment, cleanliness and availability of drinking water, and the number of different disease-causing organisms in the environment can all influence how well a vaccine will work.

Factors That Influence Vaccine Selection

Select the appropriate type of vaccine for the class of animals, their stage of production, and the disease being considered. Vaccines can be viewed as insurance or as an investment. As an investment, consider the cost of the disease against the cost of vaccination. Select a vaccine that will protect at a cost that will be less than the financial loss due to the naturally occurring disease. As insurance, consider the probability of catastrophic financial loss associated with a naturally occurring disease. In this instance, select a vaccine that will protect the operation from catastrophic financial loss, keeping in mind the cost of vaccination is like an insurance premium. Many combination vaccines are available for convenience.

However, combination vaccines may not always be appropriate. It may be advantageous to give BVD and *Hemophilus somnus* in separate injections rather than in one combination injection. This allows the H. somnus vaccine to be given SQ, avoiding damage to eatable tissue caused by the aluminum

hydroxide adjuvant. Vaccines are production management tools and are not a substitute for proper animal husbandry. Production management factors need to be considered. The objective should be disease prevention through total production management including appropriate biosecurity (*Figure 2*). However, if there is a breakdown in production management and a disease outbreak occurs, the vaccination program (insurance) needs to be adequate and effective to limit resulting losses. Thoroughly understanding causes of vaccine failure will help prevent future problems.

Figure 2. Vaccination program development.

Reduce the risk of disease by focusing on total production management. Vaccination is only one of the important production management strategies.

- Consult with your veterinarian to identify and focus on disease problems
- Isolate purchases and new additions from your other animals for 30 days
- Understand what can and cannot be accomplished with vaccines
- Outline a vaccination calendar for each animal age group
- Follow warnings, precautions and withdrawal times on the vaccine label
- Use new sterile disposable or rinse clean reusable syringes in boiling water
- Select the appropriate size needle for the animal
- Demand a valid health certificate for all new animal additions
- Consult with your veterinarian about selecting appropriate vaccines
- Vaccinate new additions to your herd as directed by your veterinarian
- Store and handle vaccines as recommended by the manufacturer
- Record animals vaccinated, vaccines used, vaccine lot numbers and dates
- Give vaccines SQ when possible
- Change needles that become damaged or contaminated and at least between every 15 to 25 animals

Note: Some diseases are easily spread by injection needles. Visit with your veterinarian about situations which will require the use of a sterile needle on each animal.

Why Vaccines Fail to Work

A vaccination fails when, following vaccine administration, the animals do not develop an immune response sufficient to protect the animal from disease exposure. The immune response has two parts, humoral (antibody protein) and cellular (circulating immune cells). When animals get sick following vaccination, the natural inclination is to blame the vaccine. Although this is certainly an important consideration, other factors must be evaluated to determine the cause of the failure.

Interference with a vaccine's ability to stimulate immunity is most commonly linked to pre-existing antibody from either a previous vaccination or passively acquired antibody from colostrum. Other causes of interference or immunosuppression include handling stress, weather stress, preexisting disease, parasitism, malnutrition, pregnancy, and steroid treatments.

Stress can lead to immune suppression and may reduce the animal's ability to mount an immune response. Stress could include environmental extremes, handling, inadequate nutrition, parasitism, and

other diseases. While it is common to vaccinate stressed animals, these animals are more susceptible to adverse vaccine reactions and frequently do not develop an adequate immune response. Immune stressed animals develop limited protection from vaccination. Frequently high stressed animals may be incubating disease at the time of vaccination. Although the subsequent sickness and death loss mimics a vaccine reaction, the underlying disease is to blame. Unless using the vaccine to stimulate immediate partial immunity, delaying vaccination of stressed animals is advisable. Similarly, properly vaccinated animals may still contract a disease if they are later stressed.

Existing antibodies to the antigen(s) contained in the vaccine can block vaccine response. Antibodies acquired through colostrum at birth are critical to the newborn's health, but only last three to six months and while present can block the immune response to a vaccine. This is referred to as Passive Antibody Interference or Maternal Interference.

Improper timing of vaccination is a common cause of vaccine failure. If an animal is incubating disease at the time of vaccination, the underlying disease may not be prevented by the vaccine. The clinical signs may mimic an adverse vaccine reaction although the symptoms are really due to a previous infection. An animal can succumb to a disease if exposed to the natural infection following vaccination before it has had time to develop an adequate immune response. The protection afforded by vaccination cannot be expected until the immune response is complete. After the first exposure to an MLV product, interferon (a nonspecific protective protein) levels rise within hours followed by antibodies detectable in approximately four to five days. Killed vaccine products require training the immune system by two vaccinations given not less than 10 days apart. With KV products the immune system is not ready to protect the animal until after a rise in antibodies following the second vaccination.

Similarly, an animal can succumb to a disease if exposed to the natural infection following vaccination if the length of time between vaccination and exposure has been longer than the protection afforded by the vaccine. Most vaccines do not ensure lifelong immunity from one or two injections.

The protection afforded by a vaccine may also be incomplete if the vaccine does not contain the proper strains or serotypes of organism required to stimulate protective immunity. Although the vaccine is administered properly and the immune system responds appropriately, the animals can still exhibit clinical signs of the disease, particularly if the animals are stressed or exposed to an overwhelming level of infectious agents. There are additional disease-causing organisms present in the environment that are not commercially available in vaccines.

Vaccine may be of poor quality (low vaccine titer, contaminated, etc.). The vaccine manufacturing industry is highly regulated by the USDA-APHIS and major manufacturers have extensive quality control programs. Vaccine failure due to faulty vaccine manufacture is rare. USDA approved vaccines will be safe and effective if used properly. In some situations, one type of vaccine may be better than another. Choosing the correct vaccine and using it properly is an important part of preventative animal health.

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