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Vaccination Failure in Poultry: Causes and Prevention

Sayed Nabil Abedin, Nur Abdul Kader, Nanda Kumar Roy and HrangchungPhunchuBappu
College of Veterinary Science, Assam Agricultural University, Khanapara

ARTICLE ID: 101

The Importance of the Vaccination in the Poultry Industry

The poultry industry faces many microbiological challenges that can affect animal health which consequently leads to a negative economic impact in poultry farms. To prevent various diseases, vaccination programs against viral, bacterial, or even parasitic diseases have been implemented. Probably, the viral ones are the most important in terms of vaccination since there is no effective antiviral therapy as such. In addition to vaccination, it is necessary to establish health and management protocols that take into account the risk factors related to the vaccine and the vaccination process itself, and factors related to the animal and the pathogen, in order to guarantee the efficacy of the vaccination and prevent it from failing.

Types of Vaccines and Techniques of Its Application in Poultry Birds

Types of vaccines-

- **Live Non-Attenuated Vaccines:** Such type is not quite common, since there are reports that the disease might reproduce and spread. There are some vaccines of this type with herpes turkey virus to vaccinate birds against Marek disease.
- **Live Attenuated Vaccines:** These are the most frequently used for prevention of viral diseases. The virus is attenuated by repeated passages in *in vitro* cultures to reduce its virulence. The attenuated virus will replicate in the animal and generate both humoral and cellular immune response.
- **Vector-Based Vaccines:** This group includes both DNA and recombinant vaccines and are the most recently developed ones. In these vaccines, the DNA of the pathogen antigen is inserted into a vector that can be either a virus or a plasmid, so that, once the animals have been vaccinated, the antigenic protein triggers cellular and humoral immune responses.
- **Inactivated Vaccines:** These vaccines contain a virus that is inactivated by either a thermal or a chemical treatment. In this case, viruses do not replicate and, therefore,

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these vaccines are less immunogenic. However, these types of vaccines have certain advantages since they produce long and uniform immunity.

The most frequent techniques for vaccine administration are:

- **Through Drinking Water:** Frequently used in the case of live attenuated vaccines, such as Gumboro disease, Infectious bronchitis, laryngotracheitis or Newcastle disease.
- **By Spray:** It is frequently used for Infectious bronchitis and Newcastle disease, and intense humoral and cellular immune responses are obtained.
- **In Ovo Administration:** Vaccine is applied in the amniotic fluid. Birds are vaccinated on the 18th day of incubation, mainly against Gumboro and Marek diseases.
- **Parenteral Administration:** A generalized immune response is obtained when using this technique.This is mainly used for inactivated vaccines and is frequent in the rearing phase of laying hens. Furthermore, some live attenuated vaccines, such as Marek disease, are also administered by intramuscular or subcutaneous injection.
- **Eye Drop Administration:** It is the most accurate method because it allows administration of exact dose of vaccine. This technique is common in the vaccination against Infectious bronchitis, Infectious laryngotracheitis, Newcastle disease, and pneumovirus. A fast and optimal immune response is obtained.
- **Aerosol:** This is a method commonly used in revaccination and is also the method of choice for to vaccinate against *Mycoplasma gallisepticum*.

The choice of the type of vaccine will depend on the disease to be vaccinated, and the route of administration will depend on the type of vaccine and the immune response to be obtained.

Vaccine Failure: Types, Causes and Prevention

Types of Vaccine Failures:

There are several factors involved in vaccine failures related to the animal, the disease causing pathogen, the vaccine or its application procedure.

1. **Animal-dependent factors :**
   - **Immunosuppressant**: Immunosuppressed animals cannot generate an adequate immune response related to the vaccination and they will not generate sufficient protection.

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- **Interference with Maternal Immunity**: Chicks sometimes receive high levels of maternal antibodies for a certain disease. In this case, if they are vaccinated in the first weeks of life for the same disease, the vaccine can be neutralized by these antibodies already present in the chicks.

2. **Pathogen-Dependent Factors :**

- **Early Appearance of Outbreaks:** The vaccination will not be effective, if the animals are vaccinated but exposed to a pathogen before the immunity develops.
- **Agent Transformation:** Several pathogens show very high genetic variability due to their mutation and recombination capacity. They change over time depending on environmental factors, thus rendering the vaccines ineffective.
- **Excessive Infection pressure:** If the infective pressure is very high, it can exceed the defensive capacity of the immune system, making the vaccine insufficient for the animal to be protected even after vaccination.

Causes of Vaccine Failure

The causes of vaccine failure can be categorized into two major factors: antigenic factor and host response.

1. **Antigenic factors**

- **Nonusage of Local Antigens:** Viral diseases like Infectious bursal disease and salmonella have several serotypes. Some of the serotypes are prevalent in one area, while others are prevalent in other areas. The local disease causing agents in any area are of prime importance for vaccine manufacturing. The locally isolated antigens and local serotypes are considered the most suitable immunogens for formulating vaccines.
- **Improper Formulation of Vaccine:** If the titter of antigen of the specific virus or bacteria is not maintained properly, the inoculums may not initiate protective immune response in birds. The dose–response relationship among the viral content, serological response and clinical protection should be evaluated at prime. Virus concentration has a significant effect on immunogenicity of vaccines. The inadequacy in formulation of vaccine and lack of standard

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procedures of vaccine formulation result in the production of non-potent vaccine.

- **Improper Storage Temperature:** The maintenance of proper cold chains and storage temperature is a prerequisite for optimal potency of vaccines. The freeze-dried vaccines require freezing temperatures, while lyophilized vaccines may be stored at 4°C. The oil-based vaccines may be stored below 8°C. In the poultry sector, almost all the vaccines available are thermolabile in nature.
- **Exposure to Direct Sunlight:**Direct sunlight has UV radiations which are lethal for vaccines containing live viruses.
- **Use of Expired Vaccines:**The use of vaccines after the date of expiry may not result in optimal immune response and can also result in vaccine failure.

2. **Host factors**

- **Immature Flock:** The age of the bird is very important at the time of vaccination. The receptors for some antigens develop in the body with advancing age. Some of receptors of virus develop as early as with the hatch of a chick. The receptors of diseases like Newcastle disease, Infectious bronchitis, etc. develop at a very early age while the receptors of diseases like Infectious bursal disease, fowl pox, etc. develop late in the body. Vaccination at a very early age before the development of certain receptors may also result in vaccine failure.
- **Immunosuppressive Diseases:**Certain diseases are immune-suppressive in poultry flocks like mycotoxicosis, Infectious bursal diseases (Gumboro), Marek's disease, etc. These immune- suppressive diseases may also lead to vaccine failure.
- **Stress on Birds:**The stress on birds can be due to a number of factors including cold stress, heat stress, high stocking density, high humidity, transportation stress, overcrowding, low per bird space, decreased ventilation, poor litter conditions, accumulation of bad smell in sheds and poultry houses, water deprivation, poor management, bad sanitary conditions, very wet or extremely dry litter, dusty environment, nutritional deficiency, and so on.

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- **Health Status of the Flock and Concurrent Diseases:** It is highly important that the vaccination should be done in healthy birds. The vaccination in sick and diseased birds may not provide fruitful results. In such cases, vaccine reaction may occur leading to extra stress and an increased morbidity and mortality rate.
- **Different Route of Administration than the Recommended Route:** Not following specific recommended routes of vaccination may result in vaccine failure in poultry flocks.
- **Inadequate Dosage:** Over dosage may lead to reaction and under dosage can lead to vaccine failure.
- **Climatic Factors:** Climate change affects the health of poultry flocks and may lead to vaccine failure and disease outbreaks.
- **Lack/Absence of Booster Dose:** Some of the vaccines require a booster dose for successful immunization. The initial dose is required for priming of vaccine while the booster is required for maximum protection against antigen. The booster dose is required after 10–20 days of the initial dose. The lack of booster dose results in low antibody titters, resulting in vaccine failure.
- **Wrong timing of vaccination:** Mostly the vaccines should be done early in the morning or later if it is during summer. The birds feel comfortable during cold hours of the day. As a result, a good response is obtained after vaccination. Otherwise, the chances of vaccine failures are increased in the case of vaccinating birds during the hot hours of the day.

Preventing vaccine failure

The following procedures can be useful for preventing vaccine failure in livestock and poultry flocks.

1. Vaccine factors

- **Proper Formulation of Vaccine:** The record of all batches of vaccines and their standard tests of vaccine potency may be maintained. Moreover, the titter of antigen should be optimal so that the proper immunity level may be provided by the vaccine.
- **Use of Local Strains of Viruses:** The local strains of antigens must be used for manufacturing of vaccine for maximum immune protection. The local disease causing

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agents of any area are specific targeted pathogens and antigens from local disease outbreaks and provide maximum protection against local disease causing organisms.

- **Proper Storage and Cold Chain Temperature:** The vaccines must be stored below 4°C. The use of thermo stable vaccines can be an alternative to overcome the difficulties related to cold chain and storage temperature. The thermo stable vaccines can maintain their potency and vaccinal activity for 1 year at 2–8°C and for 3 months up to 28°C in dried form.
- **Avoiding Exposure to Direct Sunlight:** During formulation of solution for oral or parental vaccines, direct exposure to sunlight should be avoided and for oral vaccines the cap of the vaccine vial should be opened inside water. The vaccines should be mixed in drinking water in a room or in a shady place; moreover, during the transportation of vaccine, black or colored bags and cartons should be used to prevent sunlight affecting the vaccine.
- **Avoiding Use of Expired Vaccines:** The use of expired vaccines should be avoided. Oil-based vaccines have a very narrow range of shelf life of 3–6 months. While some lyophilized live vaccines have longer shelf life of 1–2 years, provided the vaccines are stored at proper temperatures.
- **Use of Stabilizers:** Stabilizers are substances which are added in a vaccine to increase the shelf life of the vaccine. The stabilizers like Vac-Safe (Intervet), Vital Blue, etc. can be used for oral live vaccines like ND, IBD, IB, etc. of poultry.
- **Use of Immune Boosters:** There are many substances that have been used in poultry for immune stimulation. Some of them are vitamin E, selenium and levamisole. The selenium supplementation has effect on enhancing humoral immune response in chicks. The selenium supplementation increased natural resistance of increasing response of organisms to antigenic stimuli. The increased humoral antibody titers are observed when selenium is used in feed.

3. **Host factors**

- **Stress-Free Birds:** The stress on birds can be minimized by the use of vitamins and minerals in drinking water before, during and after vaccination.
- **Deworming before Vaccination:** Only healthy flocks should be vaccinated. The adult birds may be dewormed before vaccination at least 15 days before injection of

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vaccine. Diseased birds should be treated properly and vaccines should be given after recovery.

- **Monitoring of Subclinical Infections:**Some of the diseases in poultry have subclinical infections, like coccidiosis. The birds apparently seem health, but subclinical infections persist in birds over long periods of time, which have previously been infected with coccidiosis infections. On the day of vaccination, the birds should be closely monitored. The apparent health of flock should be analyzed.
- **Balanced Feeding:** The commercial feed offered to poultry should be analyzed regularly and the level of toxins be checked on a regular basis. Especially in summer and humid environment conditions, the fungus grows on feed ingredients and fungal metabolites gain entry into the body of poultry, and as a result, they cause immune-suppression, decreased growth, hypersensitivity and decreased feed intake.
- **Maturity of Bird:** Receptors for different pathogens develop in the body of poultry bird at specific ages, so the vaccination is done keeping in view the age of the bird, that is, ND + IB vaccine is done on the first day of birth. Similarly, the Marek's disease vaccine is done immediately after hatching of chicks in the hatchery machine. The IBD (infectious bursal disease/Gumboro) vaccine is done at 10–12 days of birth and booster is given after 10 days. In broiler birds, the hydropericardium syndrome (HPS)/Angara vaccine is done at 21–23 days of birth. So, the age of the bird is very important for vaccination. The domestic/rural poultry requires injection of ND after every 2–2.5 months.
- **Proper Vaccination Schedule:** In India, the outbreak of diseases like infectious bronchitis and avian influenza occurs in birds during winter; for that purpose, the birds must be vaccinated prior to winter, so that proper antibody titer may be reached in birds before exposure to the disease causing virus or bacteria in birds.
- **Host Resistance:** Certain genes have genetic resistance against viral diseases of poultry. The breeding for disease resistance may provide good long-term solutions for disease control. However, the emergence of new genetic groups and mutations require new vaccine practices for successful immunization.
- **Vitamin and Mineral Supplementation:** Vitamin and mineral supplements help to develop immune response by acting on the immune cell or by changing metabolic or

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endocrine functions and as a result, the antibodies are produced in the body at a faster rate and a protective level of antibodies is gained in a shorter time. Vitamin E and selenium have a role in modulating the immune response and have shown good results in preventing vaccine failure.

Conclusions

As described, there are several factors that can lead to vaccine failures. Some of them can relatively be kept under control, but others, such as the variability of some pathogens, are extremely difficult to control and lead to vaccination failures. For this reason, although the vaccines are essential in the prevention of many diseases, they need an extra support that increases their effectiveness against the main poultry diseases.