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Review

Practical aspects of vaccination of poultry against avian influenza virus

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Although little has changed in vaccine technology for avian influenza virus (AIV) in the past 20 years, the approach to vaccination of poultry (chickens, turkeys and ducks) for avian influenza has evolved as highly pathogenic AIV has become endemic in several regions of the world. Vaccination for low pathogenicity AIV is also becoming routine in regions where there is a high level of field challenge. In contrast, some countries will not use vaccination at all and some will only use it on an emergency basis during eradication efforts (i.e. stamping-out). There are pros and cons to each approach and, since every outbreak situation is different, no one method will work equally well in all situations. Numerous practical aspects must be considered when developing an AIV control program with vaccination as a component, such as: (1) the goals of vaccination must be defined; (2) the population to be vaccinated must be clearly identified; (3) there must be a plan to obtain and administer good quality vaccine in a timely manner and to achieve adequate coverage with the available resources; (4) risk factors for vaccine failure should be mitigated as much as possible; and, most importantly, (5) biosecurity must be maintained as much as possible, if not enhanced, during the vaccination period.

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Introduction

Avian influenza (AI) is among the most economically important diseases affecting poultry. Although much attention tends to be focused on the potential public health aspects of AI virus (AIV) infections, the impact on animal health is substantial. Control of AI has historically focused on prevention of infection, then eradication, when outbreaks occur in domestic poultry, especially with the highly pathogenic (HP) form of AI (HPAI). However, the use of vaccines in poultry has increased during the past two decades, in part because of the increase in the number of countries with endemic AI. Adding to the complexity of AI control, the use of vaccines against AI is under government control in most countries. Therefore the implementation and approach to AI vaccination can vary greatly between neighboring countries that have the same biological threat from AI, but different policies toward its control.

Vaccines against AI virus (AIV) have been available for some time and are generally safe and efficacious when used properly (OFFLU, 2013). Disincentives to vaccination include the high labor costs of vaccination in some countries and trade embargoes. AIVs of the H5 and H7 subtypes in domestic poultry are reportable to the World Organisation for Animal Health (OIE, 2012); therefore, numerous countries find it favorable to prevent infection and, if that fails, then to immediately eradicate or stamp out the virus without vaccinating.

Reluctance to vaccinate also comes from the belief that vaccines could potentiate spread of HPAI virus (HPAIV) because they can mask infection, so that poultry appear to be free of infection, but could shed virus into the environment, thus perpetuating the disease. There is evidence that the use of vaccines to control HPAIV in numerous outbreaks has not led to the virus becoming endemic (Ellis et al., 2004; Swayne et al., 2011). Also, shortcomings in biosecurity are a major contributing factor to poor control of AIV (Peyre et al., 2009b), particularly when vaccination was implemented after the virus was already endemic in a region (Swayne, 2012). If flocks are not vaccinated against low pathogenicity (LP) H5 and H7 AIV, silent infection with LPAIV could be established, increasing the chance of the virus mutating to HPAIV (Halvorson, 2002). When vaccine use has been prohibited, farmers will sometimes expose pullets to AIV to prevent later production losses (Halvorson, 2002).

Use of vaccines for a limited time during eradication to prevent the spread of the AIV within specific groups of animals represents one of the most successful uses of vaccines for control of AI (Naeem and Siddique, 2006; Swayne, 2012). In poultry producing areas where

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AIV has become endemic, vaccine may be used routinely in at-risk populations (Domenech et al., 2009; Sims, 2012).

There are pros and cons of each approach, and each has strong advocates. In view of different poultry industry structures, differences in resource availability and other variables, there is no single approach that will work optimally for every AI outbreak. However, good quality vaccines are a critical tool for minimizing losses and help to reduce the spread of the virus when used properly.

Avian influenza virus in poultry

Clinical disease

The clinical disease associated with AI in poultry has been reviewed extensively (Swayne and Pantin-Jackwood, 2008; Capua and Alexander, 2009; OIE, 2012; Swayne and Spackman, 2013; Swayne et al., 2013). AI presents with two distinct pathotypes; HPAIV causes systemic infection and LPAIV primarily causes respiratory infection. In gallinaceous birds (e.g. chickens, turkeys and quail), HPAI is characterized by rapid, high mortality and, depending on the strain, birds may present with severe lethargy, neurological signs, ecchymotic hemorrhages on the shanks, swelling and cyanosis of the comb and wattles, green diarrhea and/or heavy mucous exudate in the upper respiratory tract (Swayne and Spackman, 2013; Swayne et al., 2013).

Only some strains of the H5 and H7 subtypes of AIV have been recognized as HP. The HP form evolves from the LP form when the virus persists in a population of gallinaceous hosts. Viruses which are HP for gallinaceous birds usually do not cause morbidity or mortality in wild or domestic waterfowl, although there are some specific strains of H5N1 HPAIV that can cause disease and death in domestic ducks, e.g. Pekin ducks (Pantin-Jackwood and Suarez, 2013). Importantly, wild birds carry the LP form, except in rare situations where they become infected with HPAIV from domestic poultry.

Most AIVs are LPAIVs. The LP form can be caused by any of the 16 HA subtypes of AIV. Disease from LPAIV is typically mild and may be subclinical in domestic avian species (e.g. chickens, ducks, turkeys, geese and quail) when uncomplicated. When disease does occur, upper respiratory signs with swollen heads and lacrimation, and mild lethargy, are common (Swayne and Spackman, 2013; Swayne et al., 2013). One of the first signs of LPAI in the field is a decrease in feed and water consumption, due to reluctance to move. Transient, and sometimes severe, drops in egg production are also common (Swayne and Spackman, 2013; Swayne et al., 2013). One of the most important impacts of LPAI is that it can cause substantial losses in egg production, particularly in turkey breeders. Birds will often recover fully from the respiratory disease if they are otherwise healthy, although some strains have caused severe losses, e.g. A/chicken/AL/1975 H4N1 and some H9N2 strains (Brugh, 1992; Iqbal et al., 2013).

Risk factors for infection and disease

Risk factors for exposure of domestic poultry to AIV are summarized in Table 1 and risk factors affecting the severity of disease for chickens and turkeys are shown in Fig. 1. These host and management factors typically only affect the severity of LPAI, because HPAI is so severe that many otherwise healthy chickens and turkeys will die from the disease.

Wild aquatic birds are the natural reservoirs of AIV, which causes subclinical infection and replicates preferentially in the intestinal tract of waterfowl. The initial introduction of AIV into domestic birds frequently occurs by contact with wild birds or their excreta; typically when domestic birds have access to the outside or are provided with untreated water from nearby surface water sources where waterfowl gather. When range rearing of turkeys was phased out from around 1997, the incidence of AI in turkeys in Minnesota, USA, decreased. Conversely, animal welfare concerns have driven poultry production outside in Europe, where the incidence of AI has increased (Bonfanti et al., 2014).

Table 1
Risk factors for severity of avian influenza in poultry.

Risk factor	Causes
Season	Houses closed in cold weather have poorer air quality which can damage the respiratory epithelium and cause inflammation Cold or heat stress weakens birds and can cause immunosuppression
High ammonia levels in the house	High ammonia levels will damage the respiratory epithelium and cause inflammation
Prior infection with immunosuppressive agents	The immune system is too impaired to control infection
Prior or concomitant infection with other respiratory disease agents	Can damage the respiratory epithelium and cause inflammation
Age of birds	Very young birds and hens producing eggs may be more susceptible to infection and disease

Rearing multiple avian species together, especially mixing waterfowl and gallinaceous birds, will also increase risk of AI. Once the virus is in poultry, proximity to infected flocks and even to roads on which birds or excreta from infected flocks are moved increases the risk of infection (Akey, 2003). Population density is important to propagating the virus and areas of intensive poultry production or multiage operations have increased risk.

Consideration of these factors will influence which populations to vaccinate and the strategies adopted to optimize the efficacy of vaccination. Chickens exposed to infectious bursal disease virus (IBDV), an immunosuppressive virus, will not respond as well to AI vaccination as unexposed chickens (E. Spackman, unpublished data). In multi-age operations, pullets or incoming younger birds may need to be vaccinated if the older birds on the premise are infected.

Historical use of avian influenza vaccines in poultry

Numerous recent reviews have covered the history of AIV vaccine use in detail (Naeem and Siddique, 2006; Brown et al., 2007; Seck et al., 2007; Swayne and Kapczynski, 2008; Peyre et al., 2009a; Swayne et al., 2011). The earliest vaccines for AIV date back to the late 1920s and 1930s for HPAIV or 'fowl plague' (Todd, 1928; Purchase, 1930). More recently, worldwide vaccination of chickens and turkeys is by far most common for the H5 (HP and LP), H7 (HP and LP) and H9 (LP) AIV subtypes. Vaccination against H5 may

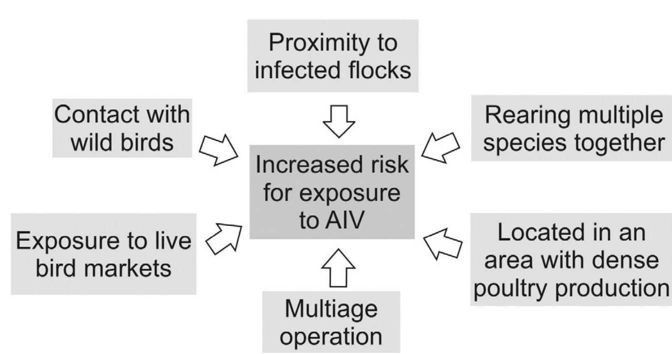

Fig. 1. Numerous factors increase the risk that a given population of domestic birds would be exposed to avian influenza virus (AIV).