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The role of vaccination in risk mitigation and control of Newcastle disease in poultry

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ABSTRACT

Newcastle disease is regarded as one of the most important avian diseases throughout the world and continues to be a threat and economic burden to the poultry industry. With no effective treatment, poultry producers rely primarily on stringent biosecurity and vaccination regimens to control the spread of this devastating disease. This concise review provides an historical perspective of Newcastle disease vaccination and how fundamental research has paved the way for the development of instrumental techniques which are still in use today. Although vaccination programmes have reduced the impact of clinical disease, they have historically been ineffective in controlling the spread of virulent viruses and therefore do not always offer an adequate solution to the world's food security problems. However, the continued development of novel vaccine technology and improved biosecurity measures through education may offer a solution to help reduce the global threat of Newcastle disease on the poultry industry.

1. Introduction

Newcastle disease (ND), caused by virulent strains of avian paramyxovirus type 1 (APMV-1), which has recently been reclassified as avian avulavirus 1 (AAvV-1) [1,2] is regarded as one of the most important avian diseases throughout the world. ND remains endemic in many countries with frequent epizootics occurring throughout Africa, Asia and the America's [3]. All strains of AAvV-1 belong to the *Avulavirus* genus of the family *Paramyxoviridae* and are regarded as a single serotype [4], however, antigenic variation between strains are frequently detected [5]. Although the majority of bird species are considered susceptible to ND, the clinical signs observed may vary and are dependent on a number of factors [6]. These include the strain of virus, host species, health and immune status as well as environmental factors. The intensive production systems employed by some poultry producers are often considered stressful and along with other associated environmental conditions e.g. high and low temperatures, or stocking densities, can increase the susceptibility of birds to disease.

The clinical signs and pathology of ND in poultry encompass a wide spectrum of disease, ranging from inapparent infections to those associated with high mortality varying with both virus strain and host. Clinical signs may include depression, inappetance, respiratory signs, torticollis, circling, reduced egg production and paralysis (Fig. 1.) Strains of AAvV-1 are classified according to their mean death time (MDT), and are generally grouped into three pathotypes on the basis of the clinical signs observed in infected chickens [7,8]. Lentogenic isolates of low pathogenicity cause mild respiratory or enteric infections, viruses of intermediate virulence that cause respiratory disease are termed mesogenic, while viruses that are highly pathogenic are known as velogenic, as defined by [9]. The virulence of NDV is dependent on a number of factors, with the F protein cleavage site sequence (amino acid residues 113–117) being the principle determinant of virus virulence [10]. The presence of multi basic amino acids at the cleavage site of virulent viruses means they can be cleaved by proteases present within hosts tissues and organs allowing the virus to spread systemically usually causing high mortality [11]. In contrast, lentogenic viruses of low pathogenicity are restricted in their ability to infect and replicate e.g. cleaved only by trypsin-like enzymes located within the respiratory and intestinal tract. However, it has been demonstrated that other regions of the Newcastle disease virus (NDV) genome contribute to the virulence and pathogenicity of the virus. The V protein has been shown to play a role in virulence through the antagonism of IFN-1 responses and may also be involved in host restriction for NDV [12]. The pathogenicity of NDV strains has been determined on the basis of various properties such as mean death time (MDT) in embryonated fowls eggs or intravenous

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Fig. 1. Chicken with torticollis and green diarrhoea characteristic of ND clinical signs. Photographs courtesy of Dr. Dennis Alexander.

pathogenicity index in six-week-old chickens. However, based on international agreement, a definitive assessment of virus virulence is based on the intracerebral pathogenicity index (ICPI) in day-old chicks (*Gallus gallus*). The variation in pathogenicity of different AAvV-1 isolates is reflected in the index range, from 0.0 (avirulent) to 2.0 (highly virulent). Strains are defined as virulent if they meet one of the following criteria, (i) the virus has an ICPI score in day-old chicks of 0.7 or greater, or (ii) the virus has multi basic amino acids at the C-terminus of the F2 protein and phenylalanine at residue 117 [3]. ND is an OIE (World Organisation for Animal Health) designated disease and detection of virulent strains of the virus requires reporting to the OIE [3] for the purposes of trade. However, due to the variability in disease presentation and the widespread use of live vaccines, differential diagnosis of AAvV-1/NDV is required before ND can be confirmed e.g. presence of a virulent cleavage site or ICPI > 0.7. This highlights the need for careful diagnosis, which is necessary for the purposes of international trade, control measures and policies.

Newcastle disease continues to be a threat and cause an economic burden to the commercial poultry industry and backyard flocks throughout the world. Since there is no effective treatment for ND, the poultry industry relies primarily on stringent biosecurity regimens and vaccination procedures for the control of this devastating disease. Since the 1930s, live vaccines have been developed to help protect flocks from the disease [13,14]. These vaccines are licensed in many parts of the world and are even obligatory in many countries. Although live vaccines have been useful in the control of clinical ND, concerns have been raised about their role in permitting the transmission of the virus and their ability to provide adequate protection against contemporary circulating strains [15,16], especially in cases where avirulent strains have mutated to a virulent form resulting in disease outbreaks [17]. This review offers a concise evaluation of the role of biosecurity and vaccination measures to protect against ND along with the consideration of advances in new vaccine development technology which may offer improved strategies to help eliminate the burden of this disease.

2. History of Newcastle disease vaccination

Vaccination for ND in domestic poultry was first proposed in the early 1930s shortly after its identification [18,19] and has been used extensively ever since, making it one of the most widely used veterinary vaccine in the world. A timeline for the development of ND vaccination since the 1930s is summarized in Fig. 2. The identification of less virulent strains such as Hitchner B_1 and LaSota [13,14] has been instrumental in the development of these vaccines and these strains are still in use today. Much of the NDV vaccine development work that was carried out during the 1970s has been fully described in the handbook entitled ''Newcastle disease vaccines: their production and use'' by Allan et al. [20], with many of the protocols still practiced today. ND vaccines have been propagated in embryonated fowls' eggs for decades; however, developments in vaccine technology have led to genetic engineering techniques where partial antigenic components are used to

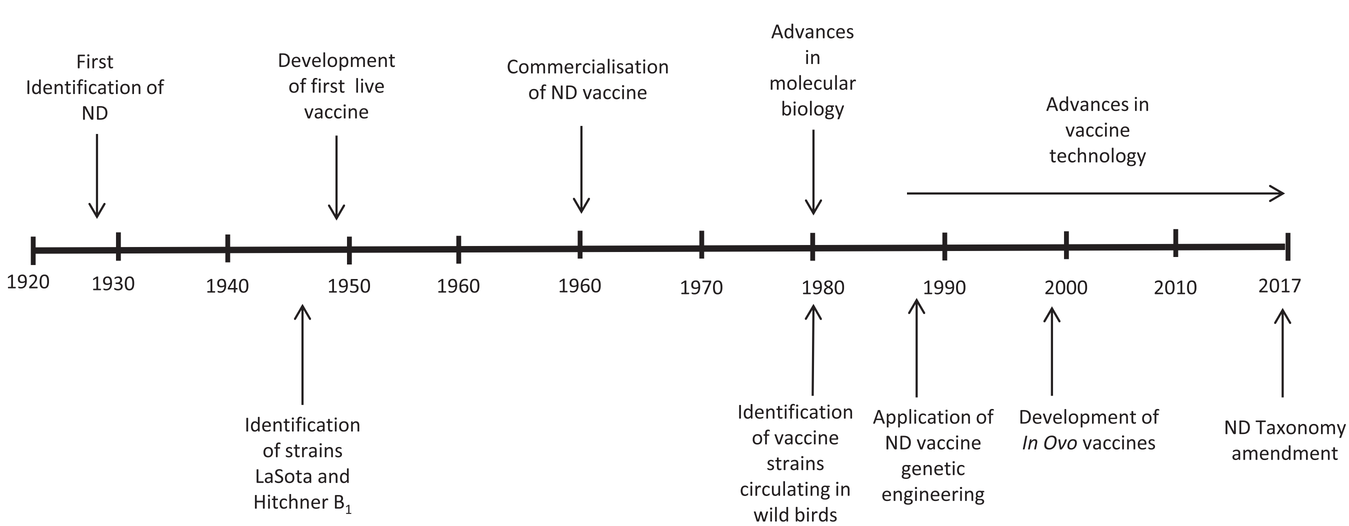

Fig. 2. Schematic summarising the timeline of ND vaccine development.

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