Prospects for the use of biotechnology for the control of Newcastle disease in Africa, Asia and South America.

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Summary

Newcastle disease in its virulent form is endemic in many countries in Africa, Asia and South America. Existing control strategies, particularly in village flocks, could be improved through the use of biotechnology. A recombinant vaccine, using a virus from the Avipox genus, would provide better heat stability and immunogenicity. Genetic improvement of chickens to make them more resistant to Newcastle disease or to respond better immunologically could be envisaged through gene transfer using a retrovirus. Immunoassays could be of value in diagnosis and vaccination control.

Résumé

La forme virulente de la maladie de Newcastle est endémique dans plusieurs pays d'Afrique, d'Asie et d'Amérique du sud. Les mesures de contrôle existantes pourraient être améliorées, particulièrement chez le poulet villageois, par l'application de la biotechnologie. Un vaccin recombiné, utilisant un virus du genre Avipox, fournirait une meilleure stabilité à la chaleur et une meilleure immunogénicité. L'amélioration génétique des poulets visant soit une meilleure résistance à la maladie de Newcastle soit une intensification de la réponse immunitaire pourrait être envisagée à travers le transfert des gènes en utilisant un rétrovirus. Les immuno-essais pourraient être de valeur pour le diagnostic et le contrôle de la vaccination.

Introduction

Newcastle disease is a fatal disease of poultry caused by a paramyxovirus (1). While it is fairly well controlled in fully industrialized countries, in many countries in Africa, Asia and South America it is endemic (11). In these countries there usually exist alongside each other industrialized chicken farms and a population of chickens kept traditionally in villages. Vaccination is usually carried out in industrialized farms, with varying degrees of success depending on how well it is done, the general sanitary conditions on the farm and the pressure of virus in the region (10,21).

However, vaccination of the traditional flocks is often not carried out. Typically, the disease is caused by velogenic strains of virus, the most virulent type, and in unvaccinated flocks mortality is very high, often 80% or more. Thus the village chicken population is periodically devastated by outbreaks of the disease, and in addition serves as a reservoir of virulent virus which exerts a constant pressure on the industrialized farms, revealing the slightest deficiency in their vaccination (3).
Consequently, any programme for the control of Newcastle disease in these countries must include control of the disease in the village population.

Two sorts of vaccine are currently used against Newcastle disease virus (NDV): a live attenuated vaccine, most often administered by mass application in drinking water in industrialized farms, and inactivated vaccine, usually administered by intra-muscular injection. These are effective under controlled conditions in industrialized farms (2), and although both the live (15) and the inactivated (20) vaccines have been used in villages their application under these conditions does present difficulties. The attenuated vaccine is heat sensitive, and is likely to be destroyed during transport to villages where temperatures are high and refrigeration is scarce. The inactivated vaccine, while being more resistant to heat and very effective when given as a second vaccination, requires some specialized skill for its application.

Recombinant vaccines

Biotechnology could help overcome these problems in two ways: firstly through the production of more suitable vaccines, and secondly through the genetic alteration of chickens to make them more resistant to Newcastle disease virus.

The technology required for the first of these is already well developed in the use of recombinant vaccinia viruses as vaccines (6). Vaccinia virus is a large double stranded DNA virus which is stable and very resistant to temperature changes. Foreign genetic material can be inserted into the virus genome using a vector which recombines with it, and the virus will express the foreign gene. Thus, for example, a recombinant vaccinia virus incorporating the glycoprotein gene for rabies virus has been used succesfully as a vaccine against rabies (4). A similar vaccine has been made for Newcastle disease with vaccinia virus and it has been shown to protect chickens against live virus challenge (12). However, in order for the vaccine to be useable in the field, it would be necessary to find a virus of the Avipox genus that could be demonstrated to be harmless, and to develop a suitable vector (such as a bacterial plasmid) for the transfer of a NDV gene that was expressed on the viral envelope. Studies on the use of recombinant fowlpox viruses are already well advanced and

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the influenza virus haemagglutinin has been succesfully incorporated into such a virus, which produced haemagglutination-inhibiting antibodies when inoculated into chickens (5). The advantage of such a vaccine would be its great stability and resistance to temperature changes and also its good immunogenicity. The efficacy of vaccinia virus vaccines has been well demonstrated by the worldwide elimination of smallpox from the human population by such a vaccine (7). In addition an important advantage of a vaccine such as that prepared by Meulmans et al. (12) expressing the F glycoprotein of NDV in a foreign genome is that antibodies induced by the vaccine would be distinguishable from haemagglutination-inhibiting antibodies induced by the wild virus. This would permit use of the vaccine at the same time as elimination of naturally infected birds, which would be of great help in erradication of the disease.

Genetic improvement of chickens

Genetic improvement of chickens could be envisaged either to make them more resistant than present to Newcastle disease or to make them better able to respond immunologically to vaccination. In order to develop such chickens, it would be necessary to both identify a differential resistance to the disease, or response to it, and to have a method for transfering genetic information from one chicken to another. Genetic differences in immune response to NDV have been studied (9,13,18), and chick mortality (8) and haemagglutination titles in eggs (14) have been studied as criteria of resistance to Newcastle disease. Wild or domesticated guinea-fowls in Africa appear to be naturally resistant to the disease (Hardouin, personal communication), but it seems unlikely that the genetic determinants for this resistance could be isolated in the absence of susceptible individuals of the same species. Investigations are planned to see if there is any naturally occuring heritable differential resistance to the virus or differential capacity to respond to vaccination in local strains of chicken in Africa.

The biotechnology required to transfer a differential resistance or a differential capacity to respond to vaccination from one chicken to another does not currently exist. However, speculatively, the use of retrovirus vectors could be postulated for this, since these viruses have been successfully used to insert genes into the chicken germline (16).

Immunological applications

Finally, biotechnology could be of use in the assesment of response to vaccination and in the diagnosis of Newcastle disease in the field. An enzyme-linked immunoabsorbant assay has been developed for the detection of antibodies to NDV (17). This is a sensitive test of the presence of disease in unvaccinated flocks, and a means of assesing the efficacity of vaccination.

A monoclonal antibody specific for vaccinal strains of NDV has been developed (19), which could facilitate differentiation between the wild-type and vaccinal viruses, and thus permit the eradication of chickens infected with wild-type virus at the same time as vaccination.

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