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Review

Immunoprophylaxis against important virus diseases of horses, farm animals and birds

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ABSTRACT

Since the refinement of tissue culture techniques for virus isolation and propagation from the mid 1960s onwards, veterinary virology has received much academic and industrial interest, and has now become a major global industry largely centred on vaccine development against economically important virus diseases of food animals. Bio-tech approaches have been widely used for improved vaccines development. While many viral diseases are controlled through vaccination, many still lack safe and efficacious vaccines. Additional challenges faced by academia, industry and governments are likely to come from viruses jumping species and also from the emergence of virulent variants of established viruses due to natural mutations. Also viral ecology is changing as the respective vectors adapt to new habitats as has been shown in the recent incursion by bluetongue virus into Europe. In this paper the current vaccines for livestock, horses and birds are described in a species by species order. The new promising bio-tech approaches using reverse genetics, non-replicating viral vectors, alpha virus vectors and genetic vaccines in conjunction with better adjuvants and better ways of vaccine delivery are discussed as well.

Contents

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1. Introduction

The first pioneering demonstration of the principle of vaccination to control a highly pathogenic infection was for smallpox in humans at the turn of the 19th century by the English doctor Edward Jenner (1749–1823) who used the ruminant counterpart of small pox, cowpox virus [1]. Since this early vaccine, the principle has been applied to control diseases caused by members of many virus families affecting humans and animals with much benefit. Although many viral diseases of production animals are truly global, there are viruses that are at present only found in some parts of the world. These viruses may however spread to other geographical regions and/or broaden their host range as has been the case for Bluetongue Virus and West Nile virus (WNV). The global viral diseases have vaccines against them while many of the regional viral diseases have no immunoprophylaxis for their control. In this respect, noteworthy example is that for the newly emergent paramyxoviruses in the genus nipah virus.

The goal of vaccination is to induce immunity in a particular species to prevent clinical disease, excretion or infection by a pathogenic micro-organism. Since the first smallpox vaccine by Jenner, numerous different approaches for vaccination have been developed. Traditionally vaccine formulations are divided in two major classes, live and inactivated (Table 1). Live vaccines contain attenuated or non-pathogenic strain of a pathogen or an expression vector. Such a vaccine is unable to induce disease but is able to induce suitable immunity; over-attenuation is a potential risk a vaccine scientist has to be aware of. It is the challenge for the vaccine developer to find the right balance between the virulence of the vaccine virus and its ability to replicate sufficiently in order to induce immunity. Attenuation can be achieved by many different ways (some examples are given in Table 1). For this, approaches used have been passaging of a pathogen in cell cultures, derivation and/or isolation of temperature sensitive mutants, which are restricted for significant replication in internal body organs. The use of related apathogenic strain by Jenner is yet another example. More modern methodology would involve the use of molecular biological techniques to remove virulence genes from a pathogen or to engineer non-pathogenic, replicating agents to express immunity inducing antigenic epitopes of a pathogen. Replication-defective vectors have also been developed as safe effective vaccines for some viral diseases. Live vaccines generally induce both Th1 and Th2 immune response and have been used in situations where antibody responses are not correlated with protection or where existing circulating antibody interferes with the induction of immunological response; interference due to maternally derived antibody (MDA) in un-weaned host is a common problem, particularly for killed vaccines administered parenterally.

Table 1
Examples of classes of vaccine formulations.

Class	Subclass	Example/reference[a]
Live vaccine	Passaging	PRRSV, human polio
	Cold-adapted/temperature sensitive	Equine influenza [18] Equine herpesvirus [6]
	Vector	Bovine adeno-FMDV [126]
	Deletion mutant	Bovine herpesvirus-1 [31]
	Chimera	Aujeski-CSFV [69]; WNV-yellow fever virus [21]
Inactivated	Whole virus	FMDV, AI
	Subunit	African horse sickness VP2 [24]
	Split virion	Human influenza
	Expression	CSFV [66]

This table serves as an example of currently used vaccine formulations and is not meant to be a complete list.

[a] See text and reference for abbreviation and detail.

For many viral diseases, killed or inactivated vaccines have been widely used as a safe option. Killed vaccines generally induce humoral immune responses and often require the use of adjuvants to boost the immune response. Adjuvants can play a major role in the direction of the immune response. Aluminium hydroxide for instance is a strong inducer of humoral immune responses, whereas others such as saponins and derivatives may induce cellular responses as well [[2], and references therein]. As is the case with live vaccines, different inactivated vaccine formulations are known, such as inactivated whole virus vaccines, subunit vaccines, peptide vaccines, and split virion vaccines.

In this overview, we look both at existing vaccines and at current approaches towards developing new, prospective vaccines for livestock, horses and birds. At this stage it is relevant to refer to the regulatory legislation controlling viral diseases of livestock in the European Union [3–5] and the vaccine development process from an industrial perspective as such [2]. It is important to point out in this respect that essential performance data are frequently limited to company registration dossiers and little information on safety and efficacy is therefore in the public domain. For many diseases