Published in : Comp. Path. 2007, Vol. 137, S2-S3
DOI:10.1016/j.jcpa.2007.04.003
Status : Postprint (Author's version)

CHALLENGES AND ISSUES OF EARLY LIFE VACCINATION IN ANIMALS AND HUMANS

P.-P. Pastoret

World Organisation forAnimal Health (OIE), 12, rue de Prony, 75017 Paris, France

KEYWORDS: maternal protection; vaccination

ABSTRACT

This overview considers the major issues related to successful neonatal vaccination of domestic animals. A major factor is the balance between the essential protection provided by maternally derived immunity and the potential inhibitory effects of this immunity on generation of the neonatal vaccinal immune response. The design of vaccine programs should also take into account the predicted life expectancy and husbandry of the animal species concerned. Relatively short-lived production animals or wildlife species may have di¡erent vaccination requirements from long-lived companion animals. The purpose of vaccination also di¡ers depending upon the animals concerned, and may range from the establishment of protective immunity in the individual animal or herd, through to programs designed to eliminate an infectious agent from a species geographical area.

Introduction

Passive maternal immune protection of newborn ani- mals was first discovered in the late 18th century by Geert Reinders, a Dutch farmer. He noted that calves born from the few cows that had survived rinderpest were refractory to further infection the ¢rst evidence of passive protection. The mode of transfer of maternal antibodies, and thereby the duration of conferred protection, depends upon the species and can take place in utero (primates), via the colostrum (cattle, pigs, horses) or by both routes (carnivores) (Pastoret et al., 1998). In multiparous animals such as carnivores, the level of protection may differ between littermates, and this is largely related to the variable uptake of colostrum by individual animals within the litter. Maternal antibodies confer passive immune protection to the newborn that is essential in early life. This transfer of immunity can be exploited by vaccinating the dam to protect her offspring in the perinatal period, for example rotavirus vaccination of cattle protects the newborn calf against one of the major pathogenic cause of early life diarrhoea.

However, maternal antibodies may also interfere with the efficacy of early life vaccination of the neonate. A well-known example in the veterinary field is the vaccination of puppies against parvovirus infection. When vaccination takes place in young puppies, the presence of maternal antibodies will neutralize the vaccine, rendering it ineffective. However, as this passive immunity wears o¡, there is a period during which the maternal antibody titre is still too high for the vaccine to be effective, yet too low to protect the pup against this disease. This lag period, during which neither maternal nor vaccinal protection are effective, is termed the "immunity gap". In practice, this problem may be overcome by giving the pup repeated injections several weeks apart (the primary vaccination series).

Vaccination in early life may be important to protect the individual later in life. For example, it is difficult to effectively protect elderly people (one of the most vulnerable groups in the population) due to age-related changes in the immune system (immunosenescence). Vaccination or exposure to a given disease early in life has been shown to confer a certain level of immunological memory later in life.

Published in : Comp. Path. 2007, Vol. 137, S2-S3
DOI:10.1016/j.jcpa.2007.04.003
Status : Postprint (Author's version)

Duration of Immunity: Lifestyle, Life Expectancy and Epidemiology

Another major difference between species is life expectancy and life style. When discussing vaccination of domestic animals, it is important to take into account the life expectancy of the species, which is determined by the lifestyle or husbandry system concerned. For example, laying hens live considerably longer than broilers and dairy cows live longer than beef cattle, while wild animals may live longer when in captivity. In this regard, the life expectancy of the red fox is 12^15 years in captivity, yet a survey showed that 75 per cent of the wild red fox population is under 1 year of age, 20 per cent is aged between 1 and 2 years, and only 5 per cent of the population is over 2 years old. The number of foxes over 3 years of age is negligible. When considering the required duration of protection for these species it is therefore clear that humans, dogs, cats and horses require life-long protection. By contrast, broilers should be protected during the few weeks of their predicted life whereas layers would require protection over the course of 1 year. Wild foxes should be protected for up to 3 years, an interval which would be extended by captivity.

The duration of protection required also varies ac- cording to the epidemiology of the infection concerned. For example, protection against canine kennel cough is only needed for the period that the dog is kennelled or exposed to other areas with a high density of dogs (e.g. dog shows or trials). Furthermore, the duration of protection and the level of efficacy expected from a vaccine may differ according to the final objective of vaccination: individual protection (such as in companion animals) or herd immunity (such as in cattle or pigs).

Disease Eradication

In veterinary medicine, vaccination can have four different objectives: (i) protection of individual (companion) animals, (ii) disease control in the population,
(iii) elimination of an infection within a region through herd immunity, or (iv) eradication of an infectious agent worldwide (Pastoret et al., 1997; Pastoret and Jones, 2004).

Foot and mouth disease (FMD) was eradicated from parts of continental Europe through mass vaccination campaigns, which were suspended in 1991. This led to a completely FMD-free, but susceptible, population. As vaccinated animals cannot be distinguished serologically from infected animals, in the face of an outbreak all positive animals (and their potential contacts) must be killed. This was the rationale underlying the decision not to vaccinate cattle and sheep during the 2001 UK outbreak of FMD.

The use of marker vaccines, also called DIVA vaccines (as they allow differentiation of infected from vaccinated animals when using specific diagnostic tests), would allow avoidance of disease control by mass slaughter (e.g. in FMD). DIVA vaccines should only be used to obtain herd immunity. Such vaccines exist or are being developed against Aujeszky's disease (pseudorabies), infectious bovine rhinotracheitis, classical swine fever, equine influenza and FMD.

The availability of an efficacious and stable vaccine is one of the requirements for eradication of an infectious agent. As stipulated by Fenner (1982), the eight conditions for disease eradication are: (i) that the dis- ease be considered important and severe, (ii) that the pathogen does not cause sub-clinical infection or is not silently excreted, (iii) that animals (including man) should not be contagious during the incubation period,

that there should be no asymptomatic carriers or recurrent excretion of the pathogen, (v) that there be only one virus serotype, (vi) that there be an efficacious and stable vaccine available,

(vii) that the infection have a seasonal incidence, and (viii) that there be no alternative reservoir of infection.

As an example of these principles, rabies in wild foxes was eliminated from western Europe with the aid of the recombinant vaccinia-rabies virus or attenuated vac- cines, given to the fox population by the oral route (Brochier et al., 1991). A side effect of the eradication of rabies was the increase in the fox population. Further diseases which have been eradicated or are near eradication include: smallpox, rinderpest, poliomyelitis, measles and peste des petits ruminants (Barrett et al., 2005).

References

Barrett, T., Pastoret, P.-P and Taylor, W.P. (2005). Rinderpest and Peste des Petits Ruminants. In: Biology of Animal Infections (series), P.-P. Pastoret, Ed, Elsevier Academic Press, Amsterdam.

Brochier, B., Kieny, M. P., Costy, F., Coppens, P., Bauduin, B., Lecocq, J. P., Languet, B., Chappuis, G., Desmettre, P., A¢ademanyo, K., Libois, R. and Pastoret, P. -P. (1991). Large-scale eradication of rabies using recombinant vaccinia-rabies vaccine. Nature, 354, 520^522.

Fenner, F. (1982). A successful eradication campaign: global eradication of smallpox. Reviews of Infectious Diseases, 4, 916^930.

Pastoret, P. -P., Blancou, J., Vannier, P. and Verschueren, C. (1997).VeterinaryVaccinology, Elsevier, Amsterdam.

Pastoret, P. -P., Griebel, P., Bazin, H. and Govaerts, A. (1998). Handbook of Vertebrate Immunology, Elsevier Academic Press, Amsterdam.

Pastoret, P. -P. and Jones, P. (2004). Veterinary vaccines for animal and public health. Developmental Biology, 119, 15-29.