Vaccination remains the only way of preventing death and debilitating disease from a number of viral conditions

Current vaccination strategies in dogs and cats

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In Practice (2009) **31**, 2-7

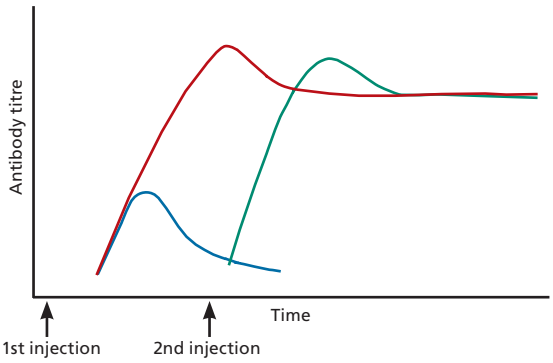
VACCINES play a vital role in controlling and preventing infectious diseases in small animals. Vaccination is an established concept for preventive health care and an important source of income for most veterinary practices. Although most veterinary surgeons administer vaccines daily, it has become such a routine part of the working day that few stop to consider the science behind this aspect of veterinary medicine. In the late 1990s, potential side effects of vaccination were highlighted by both the medical and veterinary communities, and ideal vaccination protocols have been hotly debated ever since. This article outlines the current recommendations for vaccination in dogs and cats, explains the rationale behind them and discusses some of the more recent developments in this field.

WHY VACCINATE?

Pets are usually brought in for vaccination by owners who think that:

- It will prevent death from 'horrible diseases';
- It will prevent illness;
- It is a requirement for travel (eg, rabies) or kennelling (eg, *Bordetella* species);
- It is the done thing – that is, simply that one 'should'.

The fact that some vaccines cannot prevent infection and aim to ameliorate signs (eg, feline calicivirus [FCV]) is often forgotten, as are the reasons for regulations (eg, preventing a kennel cough outbreak or the introduction of a dangerous zoonosis into the UK).



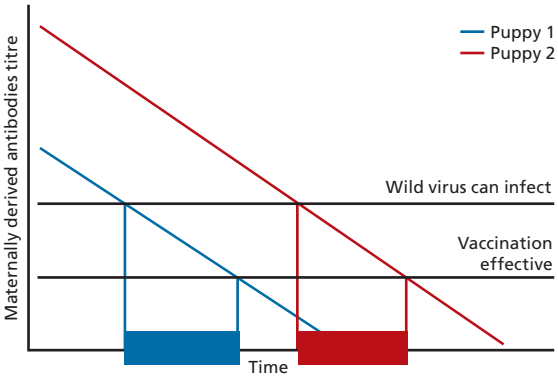
Antibody response to vaccination and infection
— Primary adaptive immune response with immunoglobulin M predominating. Note the time delay
— Secondary adaptive immune response resulting in much higher titres of immunoglobulin G after a shorter delay
— Response to modified live virus vaccine or infection

IMMUNE RESPONSE

Initial exposure to a pathogen or vaccine triggers a primary adaptive immune response during which immunoglobulin M (IgM) synthesis predominates. Continued or repeated exposure to the same pathogen stimulates a secondary adaptive response during which antibody synthesis escalates and changes to the immunoglobulin G (IgG) type. When using killed vaccines, the responses appear separately because the vaccine virus does not multiply inside the host. During a natural infection or vaccination with a modified live antigen, the pathogen continues to multiply, so both responses are triggered and overlap (see graph, below left).

MATERNALLY DERIVED ANTIBODIES AND THE WINDOW OF SUSCEPTIBILITY

Neonates absorb antibodies from colostrum. The amount of antigen available in colostrum depends on the immune status and disease history of the mother, and the amount absorbed varies between individuals in the litter according to how much colostrum is taken in. The half-life of maternally derived antibodies ranges from seven to 15 days, depending on the antigen, and antibody levels decrease at a uniform rate. As vaccine virus is attenuated, it is also less infective than wild virus. Thus, all neonates that have any maternally derived antibodies go through a stage where they have enough antibody to block effective vaccination, but not enough to prevent infection with more virulent field strains of virus. This is referred to as the window of susceptibility. A single dose of a highly effective vaccine, such as a modified live canine parvovirus



Graph showing the window of susceptibility for two puppies that have absorbed different amounts of maternally derived antibodies. The level of antibodies necessary to protect against wild virus infection is higher than the level below which vaccination is possible (intersection between the two horizontal lines and each individual puppy's graph). The time taken for the antibody to decline between these two points represents the window of susceptibility (indicated by the coloured blocks for each puppy). Thus, the window of susceptibility occurs at different times for different individuals and is determined by the initial amount of maternally derived antibodies absorbed

(CPV) vaccine, will effectively immunise a susceptible puppy. Multiple doses of such vaccines are given because it is not known when maternally derived antibodies will fall sufficiently to allow immunisation and it is preferable to minimise the window of susceptibility.

VACCINE TYPES

Vaccines made from attenuated live organisms differ from killed vaccines in a number of ways (see table, below right). Genetic modification has been used in an attempt to combine the benefits and reduce the risks of both types of vaccine, resulting in a variety of modifications, each with advantages and limitations.

SELECTING THE VACCINE BRAND

It is often assumed that all vaccines are the same and most veterinary surgeons tend to select a brand based on peripheral factors such as costs or company discounts. In some cases, the vaccines are exactly the same product repackaged and sold on under a different name. For example:

- Vanguard (Pfizer) is also sold by Intervet/Schering-Plough as Quantum;
- In the UK, Nobivac Dog (Intervet/Schering-Plough) is also sold by Virbac as Canigen;
- Leucogen (Virbac) is also sold by Intervet/Schering-Plough as Nobivac FeLV.

There are several examples where clear differences between vaccines have been demonstrated. For instance, Larson and Schulz (1997) showed that three of the six CPV vaccines on the market in the USA failed to immunise most puppies and these products were subsequently withdrawn. In 1994/95, there was an outbreak of distemper (canine distemper virus [CDV]) in Finland, which was found to be common among vaccinated dogs. Two separate studies (Ek-Kommonen and others 1997, Rikula and others 2000) showed that there was a significant difference in the immunogenicity of the vaccines in use at the time. Similar results were reported in Sweden in 1995/96 and importation of one of the offending vaccines ceased. More recently, analysis of more than 10,000 serum samples collected for the UK Pet Travel Scheme (PETS) in 2002 showed that there were significant differences in the antibody titres elicited by the rabies vaccines on the market in the UK (Kennedy and others 2007). The likelihood of dogs failing the test varied between 0·7 and 20 per cent, depending on the vaccine used. Researchers also noted that some vaccine brands showed significant differences in failure rates between batches.

There is little information available in the literature on the comparative efficacy of vaccines currently on the market in the UK.

Vaccine efficacy is determined by the product used and how it is handled

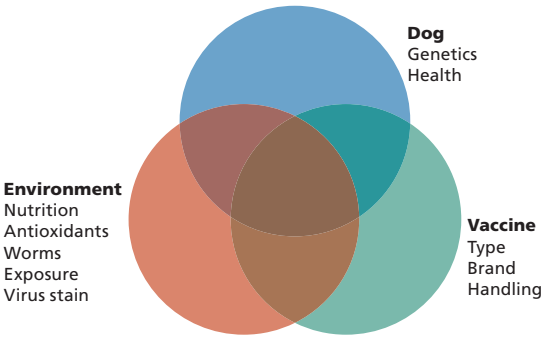
HOW GOOD ARE VACCINES AT PREVENTING DISEASE?

Vaccine efficacy is not only determined by the product, but also by how it is handled. Modified live vaccines contain live organisms that need to multiply; therefore, allowing them to warm up for long periods or come into contact with alcohol may kill virus and so markedly decrease their ability to trigger protective immunity.

An individual pet's response is determined by its genetic make-up (Greene and Schultz 2006, Kennedy and others 2007) as well as concurrent conditions, and rottweilers, dobermanns, German shepherd dogs and American Staffordshire bull terriers are said to respond

DIFFERENCES BETWEEN MODIFIED LIVE/ATTENUATED AND KILLED VACCINES

Modified live/attenuated vaccines	*Killed vaccines*
Multiply in the host, so the initial amount of antigen in the vaccine is less important	Do not multiply in the host, so need a high antigen mass
Correct handling is essential to avoid killing the vaccine virus	More stable than modified live/attenuated vaccines
Vaccine virus may mutate and become more virulent, thus causing the disease against which it is designed to protect	Cannot mutate. This is why rabies vaccines on the market in the UK for dogs and cats are killed vaccines
May cause disease in fetuses or immunosuppressed patients	Safe in immunosuppressed and pregnant animals
Have the potential for transmitting pathogenic cell culture contaminants	Have decreased potential for transmitting pathogenic cell culture contaminants
Generally result in higher titres of antibodies	Usually result in lower antibody titres than modified live vaccines against the same antigen
Usually have longer-lasting immunity than killed vaccines against the same antigen	Generally have a shorter duration of immunity than modified live vaccines against same antigen
Generally more effective at stimulating cell-mediated immunity than killed vaccines	Primarily stimulates antibody synthesis
No need to use adjuvants	Usually need adjuvants to stimulate reasonable immunity. Adjuvanted vaccines are thought to be more likely to result in allergic reactions, injection site sarcomas or pain at the injection site
Single dose may be sufficient. As vaccine virus multiplies in the host, the blue and green curves in the graph on page 2 combine	Need at least two doses for maximal protection (see graph on page 2)
Vaccine of choice for healthy animals, where available	Vaccine of choice for pregnant or immunocompromised animals



Factors affecting vaccine efficacy

poorly to vaccination when compared with other breeds (Greene and Schultz 2006). In addition, ill dogs may mount a suboptimal immune response.

Studies have shown that the addition of antioxidants to the diet can increase mean antibody titres following vaccination. Conversely, it is likely that malnutrition will dampen the immune response although it is not clear whether these effects are clinically relevant. It has been shown that worm infections decrease antibody synthesis in response to vaccination in humans and it is likely that this occurs in dogs too. The amount of virus in the environment as well as its relationship with the vaccine strain will also affect how much antibody is needed to protect an individual from showing clinical signs (see diagram above).

VACCINATION FREQUENCY

PUPPIES AND KITTENS

A single, good-quality modified live vaccine (eg, CPV, CDV) will trigger protective immunity if it is given at the correct time (ie, when maternally derived antibodies have fallen low enough). Only repeated serology will determine when a puppy or kitten will first be able to seroconvert. In most cases this is not practical, so the vaccination interval will be determined mainly by the chance exposure of the puppy or kitten to infectious diseases but should be no less than every two weeks. If given more frequently, interferon mounted in response to the first course of vaccine will inhibit antibody synthesis triggered by the second (Greene and Schultz 2006). Killed vaccines should be used no more than four weeks apart, otherwise they will lose their priming effect. Note, however, these are generalisations and manufacturers' recommendations on the use of a specific product should be adhered to.

COMPARISON OF VACCINES FOR PUPPIES/KITTENS AND BOOSTER VACCINES FOR ADULTS

Primary vaccination course (puppies and kittens)	*Booster vaccination (adults)*
Maternally derived antibodies present (half-life of seven to 15 days)	Own antibodies usually present and persist for months/years
No specific cell-mediated immunity present before vaccination	Concurrent specific cell-mediated immunity probably present
Vaccination triggers a primary (immunoglobulin M) and a secondary (immunoglobulin G) response	Vaccination triggers further immunoglobulin G synthesis if levels have fallen
More than 90 per cent of vaccinated animals are expected to respond to the primary course	Between 5 and 40 per cent of vaccinated animals can be expected to respond in the case of canine core vaccines. Much higher percentages can be expected to respond to vaccine boosters with a short duration of immunity (eg, *Leptospira* bacterins and intranasal vaccines)
Window of susceptibility	No window of susceptibility

ADULTS

In the case of canine viral antigens, adult boosters are expected to seroconvert the few dogs that have experienced a decline in immunity. In a group of 144 pet dogs in the UK that had not been vaccinated for three to 15 years, 95 per cent had protective CPV titres, 72 per cent had protective CDV titres and 82 per cent had protective canine adenovirus (CAV) titres (Böhm and others 2004).

O'Driscoll (1997), a lay author, questioned whether annual vaccination was necessary and even harmful. This was broadcast on television and started a public debate. That author's concerns were based on the findings of Duval and Giger (1996), who reported an association between autoimmune haemolytic anaemia and recent vaccination in dogs. In addition, epidemiological studies linked an increase in the number of cases of aggressive sarcoma at injection sites in cats in the USA to vaccination with adjuvanted rabies or feline leukaemia virus (FeLV) vaccines.

The Veterinary Products Committee set up a working group to determine whether UK databases could support such association, which reported 0·21 to 0·61 vaccine reactions per 10,000 doses. A retrospective study in a large hospital group in the USA found 38·2 adverse reactions per 10,000 doses of canine vaccine. The majority (65 per cent) of these reactions were urticaria, facial oedema or pruritus, while 13·5 per cent showed either a localised swelling or malaise (Moore and others 2005). The same group reported 20·34 adverse events per 10,000 doses in cats (Moore and others 2007). Seventy-five to 80 per cent of these adverse events were limited to lethargy, with or without fever or a localised swelling. Subsequent work has not been able to support the association between autoimmune haemolytic anaemia and vaccination in dogs, but the circumstantial evidence linking injection site sarcoma to vaccination is strong (see table below). DEFRA is funding an ongoing study that aims to determine the prevalence of and risk factors associated with feline injection site sarcoma in the UK.

These concerns initiated a debate about extended vaccination intervals, which subsequently led to vaccines being divided into two groups: core and non-core vaccines. Core vaccines are indicated for all animals, but non-core ones are only required for those individuals in which lifestyle, concurrent diseases or geographic situation places them at greater risk from rare or relatively less pathogenic agents.

Core vaccines are:

- Highly effective;
- Safe;
- Protective against diseases that have a high mortality or are highly infectious;
- Protective against zoonoses.

Non-core vaccines, meanwhile:

- Protect against diseases with a low mortality or those that may be treated effectively;
- Protect against diseases that only specific population segments are at risk from.

NUMBER OF SARCOMAS REPORTED TO THE VETERINARY MEDICINES DIRECTORATE IN THE UK FOR 2003 TO 2006

	2003	*2004*	*2005*	*2006*
Sarcomas related to vaccines	32	41	33	38
Sarcomas related to other products	3	2	1	1

CORE AND NON-CORE VACCINES USED IN THE UK

Dogs		*Cats*	
Core vaccines	*Non-core vaccines*	*Core vaccines*	*Non-core vaccines*
Canine parvovirus	Rabies. Obligatory for pets travelling to Europe	Feline panleucopenia	Rabies. Obligatory for pets travelling to Europe
Canine distemper virus	Parainfluenza, *Bordetella* species. Indicated in pets being kennelled or shown	Feline herpesvirus	*Chlamydophila* species. Indicated during an outbreak once the pathogen has been isolated
Canine adenovirus	Canine coronavirus. Indicated during an outbreak once the pathogen has been isolated	Feline calicivirus	*Bordetella* species. Indicated during an outbreak once the pathogen has been isolated
Leptospira species*	*Babesia* species. Pets travelling to endemic areas in Europe	Feline leukaemia virus†	

*Cases are sporadically reported in the UK, which probably justifies routine vaccination. Note vaccines do not protect against infection with all serovars
†The American Association of Feline Practitioners advises annual vaccination of all at-risk cats (ie, cats going outside). Test and removal policies have controlled feline leukaemia virus (FeLV) in catteries effectively without vaccination. Kittens less than three months old are the most susceptible to infection, with 90 per cent becoming infected if exposed. Once cats reach 12 months of age, less than 15 per cent will become infected. All cats should be tested before their first vaccination. Vaccination of an FeLV-positive cat does not change the outcome of infection, but is a waste of money in that individual and risks side effects for no benefit. If vaccination is performed instead of testing, infectious individuals may be left in contact with potentially susceptible cats. This is a risk because vaccination does not prevent clinical disease in all cases. Vaccine efficacy is difficult to assess and compare because individual products perform very differently depending on how they are tested; for example, the preventable fraction reported for Leukocell 2 (Pfizer) varies between 5 and 100 per cent (Sparkes 2003)

ADOLESCENTS

In general, a booster at 12 to 15 months of age is essential in both dogs and cats, as it seroconverts those individuals that, for some reason, did not respond to the initial course of vaccination.

EXTENDED BOOSTER VACCINATION INTERVALS

Dogs

Several multivalent vaccines are supported by challenge studies for an extended vaccination interval of three (Nobivac range, Intervet/Schering-Plough; Duramune range, Fort Dodge) or four (Procyon range; Intervet/Schering-Plough) years for the core canine antigens CPV, CDV and CAV. Pfizer has serological data to support a three-year duration of immunity (DOI) for its Vanguard vaccines (Mouzin and others 2004). Rabies vaccines are usually supported by challenge studies for a three-year DOI. It seems unlikely that more frequent vaccination with these particular products will result in an improved immunity in the vast majority of dogs (Day and others 2007). As experience has shown that all vaccines are not necessarily equal, it would be logical to use only vaccines that have data to support an extended DOI in this manner. More frequent vaccination could be considered in the face of an outbreak or if animals are malnourished or carry a severe worm burden when initially vaccinated.

Leptospirosis vaccines are killed bacterins and although challenge studies show that immunity is maintained for a year, it is thought likely that it will not persist for much longer than this. Therefore, leptospirosis vaccines need to be given annually if protection is thought to be desirable.

Cats

Much less is known about DOI to core antigens in cats. The comments about rabies vaccines in dogs applies to cats as well. Some small studies have shown that modified live feline panleucopenia (FPV) vaccines will probably result in extended periods of immunity, much like CPV vaccines. Whether the same is true for killed equivalents remains to be proven. The DOI to the respiratory components is more difficult to assess as vaccination decreases the severity of signs but does not prevent disease in a proportion of cases. In addition, there is a huge range of FCV strains and vaccines only protect against some of these. It is therefore difficult to quantify and monitor a decline in such a partial protection. The Association of American Feline Practitioners (Richards and others 2006) has advised extending intervals between vaccines for these antigens to every three years, but there are few experimental data available in the public domain to support this. The European Advisory Board for Cat Diseases (ABCD) has suggested a three-year vaccination interval against FPV and FCV, but advises annual boosters against feline herpesvirus (FHV) in adult cats (ABCD 2008). Practitioners should bear in mind that both killed and modified live vaccines are available for these antigens. It is likely that the DOI following the use of a killed vaccine will be shorter than after the administration of a modified live vaccine.

Incomplete protection and difficulties in challenging adult cats with FeLV hamper assessment of DOI for this antigen. The ABCD recommends extending the booster interval for this antigen to every two to three years after a cat reaches three to four years of age.

IS TITRE TESTING THE PANACEA?

Antibody titres assess the antibody-mediated immune response but ignore the cell-mediated one; there is no easy way of assessing the cell-mediated immune response. In diseases in which the antibody-mediated immune response is important and protective antibody levels have been determined by challenging puppies with maternally derived antibodies, the presence of antibodies provides a reasonably good estimation of immunity.

The most complete data available are for CPV. Several challenge studies have shown that puppies with maternally derived haemagglutination inhibition (HI) titres of ≥80 to ≥160 show no or only very mild signs of illness. There are some data on protective CDV antibody levels, but there is less information about CAV and FPV. There are also very few data regarding FHV and FCV. In diseases in which cell-mediated immunity is important (eg, leptospirosis, FeLV) or immunity is serosal (eg, *Bordetella* species), serum antibody titres are unlikely to assist in determining the need for booster vaccinations in most animals.

PETS has determined minimal antibody levels that prove an adequate response to rabies vaccination. As cell-mediated immunity is important to maintain protection against rabies infection and antibody levels decline relatively rapidly, rabies antibodies must be tested three to four weeks after the initial vaccination or two to three

weeks after a booster vaccination. By implication, rabies antibody titres cannot be used to assess the persistence of immunity three years after vaccination with any accuracy.

When considering the use of antibody titres to assess the adequacy of any vaccination, it is important to note:

- Adequate antibodies prove protection. Low antibodies do not mean that an animal will definitely get ill if exposed as cell-mediated immunity has not been assessed. However, vaccination should be considered;
- Which antibodies are tested. HI titres are considered the gold standard for CPV, while virus neutralisation is the gold standard for CDV and CAV. These tests prove that the antibody measured is actively disabling virus because they look for a biological effect. It is often cheaper for laboratories to use ELISA or immunofluorescent antibody tests. These assays measure all antibody directed against the antigen, so levels are usually higher but do not correlate well with protection;
- The laboratory should have its own data for validating the cut-off titres used;
- The test uses a biological system that will be subject to variation. This means that the same serum sample submitted to the same laboratory may have antibody levels up to two titres higher or lower when the test is repeated. Therefore, although cut-off titres are accurate when applied to a population of dogs, borderline titres should be interpreted with caution in individual patients.

Titre testing may be considered to:

- Evaluate a previous vaccine reaction;
- Confirm seroconversion in a puppy of a poorly responding breed;
- Assess previously diagnosed autoimmune disease;
- Evaluate an animal for PETS;
- Allay the fears of a very worried owner;
- Prove seroconversion after vaccinating a dog with a low titre.

RECENT DEVELOPMENTS

NEW VIRULENT STRAINS OF FELINE CALICIVIRUS

Over the past few years, several outbreaks of disease caused by virulent FCVs have been reported in the USA, UK and Germany (Schorr-Evans and others 2003, Hurley and others 2004, Coyne and others 2006, Schulz 2007). In these cases, vaccination did not protect cats from infection and adults were more severely affected than kittens. Mortality varied between 32 and 67 per cent. Clinical signs included upper respiratory signs and oral ulcers, acute interstitial pneumonia, subcutaneous oedema, ulceration of the foot pads, pleural and peritoneal effusions, pancreatitis and hepatic necrosis (resulting in icterus), and rarely disseminated intravascular coagulation resulting in petechial haemorrhages, epistaxis and thrombosis. Caliciviruses are highly labile and it is thought that new mutations were responsible for the increased virulence during each outbreak. Isolates within outbreaks were not identical, suggesting continued mutation, which, together with the death of many hosts, may explain why the outbreaks all appeared to die out despite the virus being highly infectious.

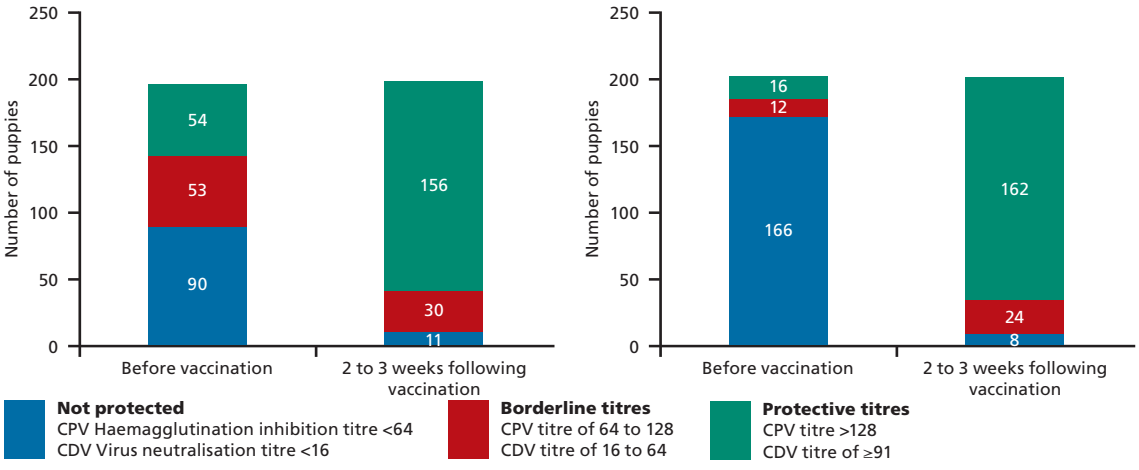
FELINE CALICIVIRUS ANTIGENS IN VACCINES LICENSED IN THE UK

Antigen	*Vaccine*
F9	Feligen (Virbac), Felocell VR (Pfizer), Nobivac (Intervet/Schering-Plough), Quantum (Intervet/Schering-Plough)
255	Fevaxyn Pentofel (Fort Dodge)
431 and G1	Purevax (Merial)

EARLY FINISH

Some canine vaccines are licensed to finish early at 10 weeks of age. This strategy was enthusiastically adopted in the UK so that puppies could be socialised at an earlier with the aim of preventing behavioural problems. The wisdom of this has recently been questioned as an apparent increase in CPV cases in juvenile dogs has been reported.

Böhm and others (2004) studied the seroconversion rates in approximately 200 puppies aged 10 to 12 weeks that were vaccinated according to data sheet recommendations by a first-opinion small animal practice in Manchester (see graphs below). Puppies were sampled on the day they received their first dose of a multivalent vaccine and again about two weeks later when they received a *Leptospira* booster. The results showed that 41 of 197 puppies had questionable or low titres to CPV when sampled for the second time, and this was similar (32 of 194) for CDV. This does not mean that all the animals would have become ill if challenged, but it is likely that some would have. These data support the conclusion that a single vaccine at 10 to 12 weeks of age may be insufficient to immunise most pet dogs.



Antibody titres of puppies before and two to three weeks after a single dose of a modified live vaccine for canine parvovirus (CPV) (left) and canine distemper virus (CDV) (right) was administered at 10 to 12 weeks of age. Adapted from Böhm and others (2004)

NEW ANTIGENS IN VACCINES

Dogs

Some companies have replaced traditional CPV type 2 (CPV-2) vaccine strains with CPV-2b strains. This is because CPV-2a and CPV-2b have replaced CPV-2 in natural infections. There is strong evidence to suggest that vaccination with CPV-2 strains results in good cross-immunity to wild strains. The jury is still out on whether CPV-2b vaccines can break through maternal immunity more effectively than CPV-2 vaccines. Note that CPV continues to mutate and two separate new strains – both referred to as CPV-2c – have been reported in Italy and Japan.

Cats

Different FCV strains are used by different manufacturers to produce vaccines. All claim broader cross-protection against field strains than their competitors. Most studies are based on cross-neutralisation studies in which a variety of field isolates of FCV are exposed to serum from vaccinated cats. Results of cross-neutralisation studies appear to vary widely and it is uncertain whether these are the best way to test vaccine efficacy. If there is an outbreak of FCV in a vaccinated colony, it may be wise to choose a vaccine with a different antigen to see whether protection against the strain involved in the outbreak can be improved.

SPECIAL CONSIDERATIONS

Vaccination while neutering	Not ideal, but studies in rescue centres show that most animals are still effectively immunised
Vaccination while on prednisolone treatment	Not ideal, but as long as doses are low (≤0·5 mg/kg daily), this should not affect antibody synthesis in dogs
Vaccinating dogs that have autoimmune disease	Consider titre testing. If titres are borderline or low, consider lifestyle, the likelihood of exposure and the likely consequences of exposure before deciding whether to vaccinate
Vaccinating cats positive for feline immunodeficiency virus/ feline leukaemia virus	Vaccinate only medically stable cats at high risk of exposure with killed vaccines. The risk of exposure should be low as retrovirus-positive cats should be isolated from other cats

SUMMARY OF VACCINATION GUIDELINES

Puppies/kittens	Age at which vaccination commences and the interval between vaccinations is determined by the likely maternally derived antibodies, the local disease risk and manufacturers' recommendations. The last vaccine should be given at 16 weeks of age
Adolescents	A booster at 12 to 15 months of age is essential
Adults	
Dogs	Vaccinate against core viral antigens every three or four years with an appropriately licensed product. Administer *Leptospira* vaccines annually. Local disease outbreaks or individual susceptibilities will determine the use of non-core vaccines or more frequent vaccination with core antigens
Cats	A three-year interval between modified live FPV boosters is probably adequate. There is currently insufficient information about the duration of immunity following FHV and FCV vaccination to provide more concrete recommendations

Non-core vaccines should only be used if specifically indicated for that individual
Modified live vaccines should be used if possible unless reversion to virulence is a risk (eg, in pregnant or immunosuppressed animals)
FPV Feline panleucopenia, FHV Feline herpesvirus, FCV Feline calicivirus

SUMMARY

Vaccination is still the only way to prevent death or debilitating disease from a range of viral diseases. Concerns about overvaccination and an increase in the number of CPV cases in adolescent dogs have resulted in close scrutiny of long-accepted policies. As a result, current recommendations concentrate efforts on core antigens, extend the vaccination course in puppies and kittens, and emphasise the importance of booster vaccinations at 12 months of age. New data from challenge studies in dogs suggest that core antigen vaccination frequency in adult dogs may be decreased with confidence. Serology may be used to further tailor vaccination protocols for individuals. There is less information on DOI and antibody responses in cats, so recommendations should be reassessed periodically as more information becomes available.

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