Canine distemper infections, with special reference to South Africa, with a review of the literature

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ABSTRACT
Canine distemper virus is a member of the genus Morbillivirus of the family Paramyxoviridae that causes severe disease in dogs and a range of wild mammals. The clinical signs relate essentially to the respiratory, gastrointestinal and central nervous systems. In South Africa, infection with Ehrlichia canis and canine parvovirus may present similarly. Many dogs will initially present with a wide range of central nervous system signs without any history of systemic disease. A recent South African study evaluating ante mortem diagnosis highlighted the importance of recognising clinical signs, cerebrospinal fluid IgG titres, serum IgM titres and immunocytochemistry of epithelial tissue. A 2-year retrospective evaluation of cerebrospinal fluid samples collected from dogs presented to the Onderstepoort Veterinary Academic Hospital indicates that distemper infection is common, and this disease should routinely be suspected in cases of diverse neurological disease in dogs. The South African dog population is specifically at high risk for the disease because of the large pool of unvaccinated, reproductively-active dogs that expose the wildlife resources of the country to risk of fatal disease. Outbreaks of disease in dogs continue to occur in developed and developing communities in both vaccinated and unvaccinated dogs worldwide, and have also been described in a wide range of free-ranging wildlife, including seals, dolphins and lions, and in endangered zoo animals. Modified live virus vaccines have contributed markedly to disease control in the dog population but have caused mortality in some wild carnivores. New recombinant vaccines are being developed that will be safe in wild animals. The pathogenesis of CNS demyelination has been compared to various important demyelinating diseases in humans and, amongst other things, relates to down-regulation of the oligodendrocyte gene coding for myelin synthesis and non-immunocyte CNS cell expression of type II major histocompatibility receptors. Early CNS lesions are characterised by demyelination and later lesions by perivascular round cell cuffing. Treatment is supportive.

Key words: canine distemper virus, dog, South Africa, wildlife.

INTRODUCTION
Canine distemper (CD) is a severe, life-threatening disease with a worldwide distribution. It was first reported in Europe in 1761. During the first half of the 19th century it was the most lethal disease of dogs. It affects mainly domestic dogs but has become a serious problem in a wide range of hosts, threatening captive and free-ranging wildlife populations including several marine mammals such as seals, dolphins and whales. Outbreaks of disease with significant mortality continue to occur amongst domestic dogs even in developed communities with high levels of vaccination. It is caused by a Morbillivirus (of the family Paramyxoviridae) similar to the human measles virus, which has decimated human populations for centuries and remains a significant cause of childhood mortality in developing countries. Rinderpest, caused by a related Morbillivirus, was responsible for great cattle plagues in Europe and Africa where it caused massive die-offs around the turn of the 20th century. It remains a threat to animal health in some developing countries to this day. CD is well established in South Africa and continues to threaten domestic dogs and wild animals. It is incumbent upon the veterinary profession as guardians of animal health to be unrelenting in tackling this problem.

AETIOLOGY
Canine distemper virus is an enveloped virus with a single-stranded, linear, negative polarity RNA genome. The latter is enclosed in a rod-shaped, helical nucleocapsid. The morphology is pleomorphic and the size varies between 100–250 nm, although many virions can be much larger and filamentous forms have been observed. It is a labile virus that is sensitive to heat, UV irradiation, lipid solvents, detergents and oxidising agents. It can survive at room temperature in tissues and exudates for between 20 minutes and 3 hours. In environmental temperatures below zero it will survive several days if protected by organic material.

EPIDEMIOLOGY
Canine distemper has a worldwide distribution and affects a wide range of mammalian hosts (domestic and wild, land and sea-living). The virus is readily transmitted between susceptible hosts and the dog remains the most important reservoir for the infection. Because morbillviruses do not persist in an infectious form following an acute infection, and infection results in life-long immunity in recovered hosts, the virus needs a constant supply of susceptible hosts for its maintenance. Virus is shed in the stool, saliva, urine and conjunctival and nasal exudates during the acute phase of the infection.

In a developing peri-urban community of southern Africa, disease incidence was highest in the spring and early summer months of August to November. The age at which the highest incidence of infection occurs depends on whether the disease is enzootic or epizootic. In a susceptible population, all ages are susceptible. Enzootic disease, on the other hand, tends to affect mainly young dogs. Aerosol and droplets are the most important means of transmission. Virus may be shed for between 60 and 90 days following infection, although shorter periods are more typical. This has bearing on the decision...
A constant supply of puppies is a challenge for the veterinary services. A scenario that becomes very difficult to control is an isolation ward for outpatients. A direct viral effect on B cells or their precursor cells in the bone marrow is plausible.

The neurobiology of demyelination in CDV infection is of particular interest and has been the topic of several studies, as it is regarded as a model of human demyelinating disease. The acute demyelinating lesions are non-inflammatory, develop during a period of severe immune suppression, and coincide with replication of virus in glial cells of the white matter. An obvious explanation for this would be infection of the oligodendrocytes, which are the myelin-producing cells. Viral protein is, however, only rarely demonstrated in these cells, and in fact it was initially believed that oligodendrocytes could not become infected with virus. Astrocytes are the most commonly-infected cells. Although viral protein is not produced in oligoden-
Microglia and astrocytes expressing MHC II would allow presentation of self antigens that could lead to virus-independent demyelination. In chronic lesions, MHC II was found to be highly expressed despite the absence of viral antigen, suggesting that demyelination may be triggered and perpetuated by non-viral (self) antigens.

Antiviral immune responses have been blamed for 'bystander' demyelination. Macrophages constitute an important proportion of the cells that respond to infection. These cells have been shown to play an important role in producing reactive oxygen species that lead to selective destruction of oligodendrocytes as 'innocent bystander' cells. It has also been shown that CDV infection leads to enhanced macrophage activity and hence enhanced destructive activity.

It is important to realise that viral clearance results in CNS recovery and only persistent infection of the CNS can lead to a progressive smouldering inflammatory reaction. It is possible for virus to persist in white matter areas outside the inflammatory demyelinating lesions or even in the periphery of such lesions. Mechanisms allowing such persistence are poorly understood but are obviously important to the evolution of disease and are the topic of ongoing investigations.

Cytokines play a significant role in any disease in which inflammation contributes to the disease process. To date there have been few studies evaluating the effect of cytokines in CDV infections. One of the hindrances to this type of work in dogs is the lack of species-specific reagents. One study evaluated mRNA expression of interleukin 1 (IL-1), IL-6, IL-8, IL-12, tumour necrosis factor α (TNF), interferon γ (IFN) and TGFβ in whole blood using reverse transcriptase polymerase chain reaction (rt-PCR). No significant correlation between disease and cytokine mRNA expression was demonstrated. No cytokine transcripts could be found in the blood of any of the acutely viraemic dogs with a high viral load. This may have been due to immune suppression. Pro- and anti-inflammatory cytokines revealed no clear pattern of expression. It is highly probable that the form of disease, immune status of the individual and time of sampling all impact cytokine expression. Circulating levels of cytokine mRNA may also be poorly correlated with cytokine protein production at tissue level. Another study examined mRNA expression of various cytokines in the CSF of naturally-infected dogs. IL-10 was found to be the most commonly expressed cytokine, although both pro- and anti-inflammatory cytokines were co-expressed in most cases, making it very difficult to link expression with pathogenic effect. A further problem is the heterogeneous nature of CNS lesions at any time. Both non-inflammatory and chronic inflammatory lesions co-exist in the same brain at any particular time. Furthermore, determining cytokine mRNA expression in CSF may not relate to what is actually taking place in the brain tissue. One case with advanced chronic lesions expressed only TNF and IL-12. Ideally, it would be possible to study the cytokine kinetics in brain tissue over time at the same time as being able to evaluate inflammatory cell phenotype.

Clinically, demyelination is a common feature of chronic CDV infection. Cytokine expression in tissue sections correlates well with the demyelinating process. A case of disseminated parvovirus infection with widespread demyelination was reported to have very high levels of IL-12 and IL-6. The high levels of these cytokines in this case may indicate a significant role for these cytokines in the pathogenesis of parvovirus-induced CNS demyelination.

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can be catastrophic. Problems with CDV infection following discharge from hospital of puppies that had parvovirus infection is likely in these circumstances.

The form of the disease that presents most commonly depends especially on the level of immune competence of the population and age of the affected dogs. Clinical signs therefore vary widely. In unvaccinated dogs and unvaccinated puppies (of between 12 and 16 weeks of age when maternal antibody titres have waned) the severe generalised catarrhal form is most common. These dogs are febrile, with mucopurulent conjunctivitis, upper respiratory tract signs, depression, anaemia, vomiting and diarrhoea (which may be bloody). Severe dehydration and weight loss may be present. Adequate treatment in this group may reduce the mortality rate.

The most common form of the disease seen at the OVAH is the neurological form in older dogs. The disease occurs frequently enough to justify investigation for CDV infection in all dogs showing non-surgical spinal cord disease and in all dogs with brain signs.

In an outbreak described in an urban dog population of the Copenhagen area in Denmark, more than half of the cases presented with the catarrhal form. Many of these dogs also had CNS involvement and digital hyperkeratosis (so-called ‘hard-pad’). In an outbreak described amongst unvaccinated sled dogs in northern Greenland (with a mortality of 1000 of a population of around 3000), most died within a week with classic catarrhal and nervous signs. Digital hyperkeratosis was not observed. Blindness was observed in a few survivors. In a Finnish study of an outbreak in approximately 5000 vaccinated dogs with a mortality of 30%, the majority showed classic catarrhal and nervous signs. Digital hyperkeratosis was not observed. Blindness was observed in a few survivors. In a Finnish study of an outbreak in approximately 5000 vaccinated dogs with a mortality of 30%, the majority showed classic catarrhal and nervous signs. Digital hyperkeratosis was not observed. Blindness was observed in a few survivors.

Typically, neurological signs follow the catarrhal signs within about 2–3 weeks. As demonstrated by previous studies and observations cited above, many dogs will present for the first time with neurological signs preceded by no or very mild signs. In one report, only one third of cases with neurological disease had a previous history of systemic signs, and another third had no previous history of disease at all. Once CNS disease manifests, it is usually progressive, without a relapsing course, although a chronic relapsing course has been described. Neurological disease often appears localised according to clinical examination, despite the diffuse viral and lesion localisation. Signs are very varied but commonly include seizures, blindness, central vestibular disease, cerebellar signs, brain stem and spinal cord disease. Myoclonus occurs in about one third of cases and is most commonly associated with CDV, but should not be regarded as pathognomonic, as it is seen in other causes of meningoencephalomyelopathies. It is seen most commonly in the muscles of mastication and the limbs, but may be seen in any muscle group. Naso-digital keratosis is reported to occur in about 8 % of cases with neurological disease. Bi- or unilateral optic neuritis is often the cause of blindness. Swelling of the optic disc may be seen in the acute disease. Ill-defined grey to pink densities may be seen in the tapetal and non-tapetal regions. Chronic disease may cause well-delineated hyperreflective retinal areas. The immune compromising nature of the disease results in the frequent occurrence of secondary bacterial infection of the skin and respiratory tract which are features of the acute phase of the disease. The activation of other unusual and CNS infections owing to the immune suppression caused by CDV has been reported, and these infections include combinations of CDV and Toxoplasma gondii, Neospora caninum, Filariodes hirti, cryptosporidiosis, Pneumocystis carinii and canine infectious hepatitis virus.

CDV infection has been associated with inflammatory joint diseases and hypertrophic osteodystrophy (HOD) in dogs. In a study of experimental infection of gnotobiotic dogs CDV infection of the proximal metaphyses of the humerus was prominent. Antigen was abundant in the marrow, osteoclasts and osteoblasts, where it had a direct cytolytic effect, even causing cell necrosis. There was a strong association between CDV antigen presence and osseous changes. CDV antigen has been reported in the bone of humans with Paget’s disease and an association between dog ownership and this disease in man has been postulated. There is, however, very little evidence for this, and other studies have failed to support this hypothesis. A similar link between CDV infection and multiple sclerosis in man has been suggested, but there is no proof of this association, and CDV should be regarded as an animal disease with no public health risk. In an earlier study linking CDV infection and HOD, dogs infected with serum from HOD patients developed CDV signs and the infection was confirmed at necropsy. CDV has also been demonstrated by rt-PCR, in situ hybridisation and southern blotting in the bone tissue of dogs with HOD. It is possible that all dogs with CDV infection develop sub-clinical bone disease, especially considering that dogs with HOD develop constitutional signs of disease such as fever and malaise. Infection during puppyhood may cause enamel hypoplasia in the permanent teeth seen in adulthood.

A rare progressive condition that has come to be called ‘old dog encephalitis’ is purported to occur in dogs that have survived CDV infection. It is characterised by widespread perivascular lymphoplasmacytic infiltration in areas of demyelination and neuronal degeneration. In some cases it has also been described as a sclerosing panencephalitis with infiltration and replacement of nervous tissue by a dense astrocytic network. Clinical signs are typically restricted to lesions typical for the cerebrum and exclude involvement of the brain stem, spinal cord and cerebellum.

A link between juvenile pyoderma and CDV has been suggested. A pustular skin disease is not uncommon in CDV infection and has been described as an ‘allergic response to the virus’. In a recent report, 3 of 4 dogs recently vaccinated with a modified live CDV vaccine developed juvenile cellulitis and radiographic evidence of HOD. The skin disease was successfully treated in all 4 dogs with prednisolone. Distemper-like skin lesions have also been described following inoculation with a modified live virus vaccine. The concurrence of HOD and juvenile cellulitis has been reported previously.

**EXPERIENCE WITH THE DISEASE IN SOUTH AFRICA**

A retrospective study of cerebrospinal fluid samples submitted to the Department of Veterinary Tropical Diseases, Faculty of Veterinary Science, University of Pretoria, Onderstepoort, from dogs with clinical signs compatible with CDV infection was conducted during 1998 and 1999.

One hundred and thirty-three CSF samples were submitted during this 2-year period. Thirty-four (25 %) were found to be positive for CDV-specific IgG. Of these 34 cases, 23 showed nervous signs only (including tremors, vestibular syndrome, hind-limb ataxia, progressive ataxia, seizures, myoclonus, depression, periodic neck pain, generalised body pain and dementia). A combination of neurological signs with gastrointestinal signs was seen in 4 cases. No dogs were observed to have a combination of neurological and respiratory signs. The typical non-neurological signs seen were purulent oculonasal discharge (4 dogs) and respiratory signs (2 dogs) that included
pneumonia-induced coughing and increased respiratory rate. The gastrointestinal signs observed were anorexia, diarrhoea and vomiting (4 dogs). No cases of digital hyperkeratosis (so called “hard-pad disease”) were noted. Nineteen of the 34 CSF CDV-specific IgG-positive dogs were less than a year old, and 12 of these were presented with only neurological signs. The remaining 15 dogs were older than a year, 2 being older than 7 years. Fourteen of these 15 dogs older than a year showed only neurological signs. No seasonal incidence was noted over the 2 years. The results of this study highlighted several important issues about the disease as it is seen at the OVAH. These include:

- **CDV infection is sufficiently common in the OVAH environment to justify ruling out this disease early in the course of the investigation of diverse neurological signs.** (See ‘Diagnosis’ below).

- **Neurological signs are the most common presentation.** Catarral signs combined with neurological signs are the next most common presentation. Catarral signs alone are an infrequent presentation. The neurological presentation is the most common in all age groups and especially common in dogs older than one year.

- **Digital hyperkeratosis is an uncommon sign.** At a satellite clinic of the Medical University of Southern Africa that served a more resource-deprived community than the OVAH, catarral signs alone and in combination with neurological signs were more common than neurological signs alone.

In a retrospective evaluation of 154 dog brains presented to the OVI for rabies diagnosis between July 1992 and July 1993, a final diagnosis of CDV was made in 26 cases. Diagnosis was based on immunoperoxidase staining for inclusion bodies in at least 1 of 6 standard sections. Other common diagnoses included cerebral babesiosis, E. canis infection and granulomatous meningoencephalitis (J J van der Lugt, pers. comm., 1999).

**DIAGNOSIS**

Diagnosing canine distemper in the live animal with confidence remains difficult, yet very important because of the implications of the disease. Identifying typical clinical signs still remains the most important initial diagnostic step. Because the disease often has a poor prognosis and has a high infectious potential, ante mortem confirmation of the diagnosis is preferred. The many varied clinical presentations of the disease (especially in its neurological form) may also dictate that clinical signs are by no means typical, further emphasising the need for a definitive diagnostic test. Numerous different methods that have been used for diagnosis testify to the difficulties experienced in this regard.

The most common haematological finding is lymphopenia. In a local study 86% of 30 dogs with CDV infection were lymphopenic. Thrombocytopenia may also be present. A left shift neutrophilia may be helpful in confirming the presence of significant secondary bacterial infection. In the South African setting, because of the frequency of other concurrent infectious diseases, haematological findings may be varied if mixed infections are present. Other immune-suppressive infections (such as ehrlichiosis or parvovirus infections) can induce very similar haematological abnormalities. This is especially relevant because many of the dogs suspected of having distemper infection live in developing communities where infectious diseases are very common and vaccination is seldom practised. Viral inclusions in the white or red cells are rarely observed. Serum biochemistry is usually unremarkable. Radiology may demonstrate an interstitial (viral) pneumonia in early cases and an alveolar pattern with bacterial pneumonia later in the course of the disease.

CSF and serological abnormalities and the demonstration of viral inclusions in epithelial cell cytology (by fluorescent antibody techniques) are usually the most practical and useful means of confirming a diagnosis.

The diagnosis of inflammatory diseases of the canine CNS is usually difficult, with at least one third of cases remaining undiagnosed in the live animal despite thorough investigation. However, results of analysis of the CSF of CDV-infected dogs are frequently useful in diagnosis. Raised protein content and lymphocytic pleocytosis are common. In the study by Carter, 89% of the 30 CDV positive dogs examined had CSF protein concentrations in excess of 0.5 g/l (normal is <0.25 g/l), and lymphocytes were also the most frequently-encountered cells. Finding anti-CDV IgG antibodies in the CSF is definitive in CDV encephalitis, as the antibody is locally produced. This is not the case in vaccinated dogs or dogs without CNS CDV infection. Vaccinated or exposed and cured dogs should all have a blood IgG titre that, if present in CSF, would indicate blood contamination during CSF collection. This problem can be overcome by determining concomitant Parvovirus titres in both serum and CSF. If there has been blood contamination of the CSF, a Parvovirus titre will be present in the CSF if it is present in the blood. The only way that this could have occurred is by contamination, as anti-Parvovirus antibodies are not synthesised intrathetically. An IgG index may also be calculated comparing CSF CDV IgG titres to CSF albumin concentrations.

Immunocytochemical examination of smears from the conjunctiva, tonsillar, genital or respiratory epithelium may demonstrate virus if smears are made early in the course of disease (within 2 weeks post-infection). Finding antigen by this method in buffy coat smears would also confirm a diagnosis, but only during the early brief viraemic phase of the disease (usually within 10 days post-infection). As antibody titres rise, antigen is either bound and masked from immuno-staining, or disappears from the epithelial surfaces altogether. A recent report has demonstrated the usefulness of CDV-specific immunoperoxidase histochemical test in skin biopsies (foot pad, nasal mucosa and haired skin from the neck) in diagnosis. Biopsies from the haired skin from the neck were likely to be positive as epithelium from the other sites in this study. This method proved useful in acute and subacute disease. Although the experience base with this method is small, its efficiency, ease and cost-effectiveness should encourage wider use. Immunocytochemical staining for antigen has also been successful in cells from CSF and urine.

Detection of serum IgG and IgM titres has been widely used. Because of the practice of vaccination and the frequent exposure of dogs to self-limiting infection, detecting a positive IgG titre in serum is of very little value in confirming a diagnosis. A positive IgM titre, on the other hand, should be interpreted as recent exposure (during the last 3 weeks) to vaccine virus or natural infection. With the advent of molecular biological technology, rt-PCR has been used to detect viral nucleic acid in blood, serum and CSF. This highly sensitive and specific mode of diagnosis can be expected to be widely used in future.

Virus isolation is useful, but special arrangements need to be made with the diagnostic laboratory concerned. This technique is usually reserved for research environments and has proven useful to differentiate natural infections from vaccine-induced disease in exotic species. Vaccine strains can replicate in macrophage, lymphocyte and epithelial cell cultures, whereas field strains require several blind passages to replicate in epithelial cell lines.

In a South African study Carter examined 30 dogs with clinical signs suggestive
of CDV from a developing community. All dogs were euthanased and necropsies performed and CDV infection confirmed on histology of the brain. Analysis of the CSF for distemper yielded the following information:

- The indirect fluorescent antibody test for viral antigens in cells from the CSF had a sensitivity of 27% and a specificity of 100%.
- The indirect fluorescent antibody test for IgG in the CSF had a sensitivity of 64% and a specificity of 100%. No IgM was detected in any of the cases by using this method.
- 89% of dogs had a protein concentration of 0.5 g/l or more.
- Direct fluorescent antibody testing on conjunctival scrapings had a sensitivity of 37% and a specificity of 100%. Impressions made of the tissue of the footpad had a sensitivity of 23% and specificity of 100%.

Blood analysis showed:

- An indirect fluorescent antibody (IFA) test for IgG in serum had a sensitivity of 96% but a specificity of 0%.
- IFA for IgM in the serum had a sensitivity of 75% and a specificity of 80%.
- 86% of cases had haematocrits below 0.4/l and 49% were thrombocytaemic.
- 86% were lymphopaenic.

This study concluded that the following tests, in order of preference, were helpful in confirming the ante-mortem diagnosis of CDV:

1. IFA for IgG in the CSF in cases of CDV encephalopathy.
2. IFA for IgM in the serum.
3. Direct fluorescent antibody testing for CDV antigen in conjunctival scrapings.
4. Direct fluorescent antibody testing for CDV antigens in cells in the CSF of cases with CDV encephalopathy.

These findings have proven useful and practical in the resource-deprived communities of South Africa. A similar survey of diagnostic tests in dogs from developed areas has not been performed, and would probably yield slightly different results because the acute catarrhal form of the disease is rare in this population of dogs. Most CDV disease in developed communities is of the chronic neurological type. In this setting, CSF IgG titres are most useful, but fluorescent antibody testing of cellular material for analysis is less useful. Reverse transcriptase PCR of CSF fluid may prove to be useful in the future.

**CANINE DISTEMPER VIRUS INFECTION IN WILDLIFE**

Although CD is an important disease in dogs, there have been some alarming distemper outbreaks in non-domestic species, which further highlights the importance of control of the dog reservoir. Eight of the 11 families of the order Carnivora are susceptible to CDV, with a mortality rate that varies widely between species. Of the species in which CDV infection has been reported, the following occur in South Africa: lion, leopard, wild dog, hyaena, foxes and otters. Of these species, exposure to CDV has been demonstrated serologically in lions, leopards and wild dogs. However, no catastrophic mortality due to CDV infection has been reported in southern Africa. Distemper outbreaks have been reported in captive lions, tigers, leopards and jaguars in North America. Most of these animals die of CN5 disease following respiratory and gut involvement.

Outbreaks have been reported in marine mammals, including seals (so called phocine distemper) and striped dolphins. Thousands died in the Mediterranean between 1990 and 1992. It is most likely that these outbreaks originated in terrestrial carnivores. A massive CD outbreak in the lion population of Serengeti (Tanzania) killed about 30% of the lion population of that area in 1994. The same area experienced CDV-related deaths in bat-eared foxes, African wild dogs, spotted hyaena, common jackal and silver-backed jackal. The source of these infections is purported to be the domestic dog population of about 30 000 that surrounds the park. Several years later 55% of the lions of Maasai-Mara were found to be serologically positive for CDV, indicating exposure. Preventing the spread of this disease to wildlife would require vaccinating all dogs around the conserved areas or vaccinating the wildlife, which is not practical in free-ranging wild animals. Developing a vaccine that is safe in captive wildlife remains a challenge, as there have been several reports of disease caused by the use of modified live CDV vaccine. It would be ill-advised to use a live vaccine in captive wild animals. In this regard, inactivated vaccines (which are no longer commercially available) are best used. Recombinant or subunit vaccines would be desirable for captive wildlife.

**PREVENTION**

Vaccination remains the mainstay of preventing CDV infection in dogs, and therefore a large amount of research and a large industry has developed around this practice. Maternally-derived antibody provides temporary protection to neonates for a period that varies from days to months. This phenomenon has been responsible for the use of a modified live measles virus vaccine. The 2 viruses are antigenically closely related, and the measles virus is not neutralised by the maternal antibody in 6-week-old puppies. The second and all subsequent vaccines are modified live virus vaccines, as by this time maternal antibody titre has waned to the point of being inconsequential. This long-accepted practice of 'heterotypic' vaccine use has been questioned, as ongoing usage of measles vaccine means that progeny of bitches vaccinated with measles vaccine may possess maternal antibodies against measles virus that would interfere with early measles vaccine in puppies born to them. It has been shown that a high-titre CDV vaccine is even more effective in protecting 6-week-old puppies against experimental distemper challenge than the traditional human measles vaccine. It is generally accepted that vaccination should take place every 2-4 weeks from the age of 6 weeks until 12 weeks, and then yearly thereafter with a modified live virus vaccine. Frequent vaccination has been practised in an attempt to reduce losses early in life. It has been shown that 'mature' vaccination (every week from the age of 2 weeks until 10 weeks and then at 12, 16, 18 and 24 weeks) gave no better protection than a 'minimal' regime (5, 9, 13, 17 and 22 weeks) in Greyhound puppies. There was also no adverse effect on cellular immunity of the maximal protocol. Inactivated vaccines do not provide protection against experimental challenge infection. A canine pox recombinant vaccine has recently been developed that provided good protection and is now commercially available.

The need for yearly booster vaccination is often questioned, and in fact in developed countries the recommendation is now that booster vaccinations are only required every 3 years following the initial puppy series and a booster at one year. Boosters for geriatric animals are discouraged. Sufficient levels of neutralising antibodies remain in serum for longer than 6 years after vaccination. It has, however, been claimed that, on the basis of serum antibody titres, annual vaccination should be maintained. On the other hand, it has been suggested that humoral immune mechanisms alone do not account for immunity and that protection lasts much longer than indicated by antibody titres. In a country such as South Africa, where most dogs are unvaccinated and reproductively active, and where a large wildlife resource is potentially at risk, it would be unwise to...
recommend anything other than yearly booster vaccination.

Not all vaccines are equally effective, as has been demonstrated in numerous comparative studies on the efficacy of various products. Outbreaks of disease have been described in well-vaccinated populations, as indicated above. Despite these reports, the chances of outbreaks are greatly reduced in well-vaccinated populations. It has also been shown that there is a concentration of a particular batch of vaccine. Further, cephalitis were recorded in dogs in populations,

are greatly reduced in well-vaccinated populations, as indicated above. Despite these reports, the chances of outbreaks have been described in well-vaccinated populations, as discussed with the owner. The possibility of neurological signs developing should be discussed with owners. This remains an important reason for euthanasia but before this is done, it is worth considering treatment for a period of time in a select group of patients, as some dogs may recover. Patients for which euthanasia should be considered include: 1) those dogs with neurological disease that compromises quality of life (such as intractable seizure activity, severe myoclonus or incapacitating spinal cord disease), 2) severe and worsening catarhal forms of the disease, or 3) dogs that come from multiple-dog households where other dogs may be at risk of infection.

Supportive treatment for dogs likely to be shedding virus should be administered on an outpatient basis as far as possible unless the dog can be barer nurse in isolation. This is frequently a problem in the private practice situation in South Africa where most isolation facilities are still used for Parvovirus-infected puppies. CDV suspect dogs should not be treated in proximity to these patients. Antibiotic cover (broad spectrum and effective in the respiratory tract), fluid and electrolyte balance (including anti-emetics if required), nutritional support and seizure control form the basis of a management plan. Good nursing care such as keeping the animal warm and dry and cleaning ocular/canaline discharges should be applied. Various homeopathic treatment claims have been made. These are scientifically unsubstantiated.

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