Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Guest editorial

Canine parvovirus post-vaccination shedding: Interference with diagnostic assays and correlation with host immune status

Canine parvovirus (CPV), along with canine coronavirus, is one of the main agents of canine acute gastroenteritis (Decaro and Buonavoglia, 2008, 2011, 2012). Young puppies, usually from 2 to 6 months of age, are mainly susceptible to CPV infection and overt disease, but clinical cases are being documented with increasing frequency in adult dogs (Decaro et al., 2008, 2009). The main route of infection is oronasally, through contact with the faeces of infected dogs or contaminated fomites, facilitated by the exceptional resistance of the virus in the environment. Clinical signs usually include inappetence, depression, vomiting and haemorrhagic diarrhoea, although non-haemorrhagic diarrhoea is observed in a high proportion of CPV-infected animals (Decaro and Buonavoglia, 2012).

The original canine virus, CPV-2, emerged in the late 1970s as a host variant of the well-known feline panleucopaenia virus (FPLV), but in few years the old strain disappeared due to the emergence and spread of three different antigenic variants. The first two variants (CPV-2a and CPV-2b) appeared in the early 1980s, whilst the third type, CPV-2c (Buonavoglia et al., 2001), was detected as early as 1996 (Decaro et al., 2007a). Currently, CPV, FPLV and other related parvoviruses detected in wild carnivores are included in the same viral species, *Carnivore protoparvovirus 1* (Family: Parvoviridae; subfamily; Parvovirinae).

After infection with field variants, CPV is able to induce viraemia that lasts up to 60 days, as detected using real-time PCR (N. Decaro, personal observation), whilst virus shedding through the faeces is detected, using molecular methods, for as long as 50 days (Decaro et al., 2005). Faecal ELISA antigen tests are available for in-clinic testing of dogs in which CPV infection is suspected. These assays are rapid and practical, but they have the disadvantage of poor sensitivity, being able to detect the virus for only a few days (Desario et al., 2005). However, all the three CPV variants are detected with the same efficiency (Decaro et al., 2010, 2013).

Vaccination against CPV has been suspected to interfere with diagnostic tests. CPV-2 and CPV-2b modified live virus (MLV) vaccines, available commercially, are able to replicate in the enteric tract, thus being shed with the faeces of vaccinated dogs. This may lead to a diagnostic dilemma when pups that have been administered a CPV vaccine recently are presented with clinical signs of acute gastroenteritis (Decaro et al., 2007b). A recent study has tried to address this issue by evaluating the duration and extent of CPV viraemia and faecal shedding in pups with maternally derived antibodies not interfering with active immunisation and that were vaccinated with either CPV-2 or CPV-2b formulations (Decaro et al., 2014). Using real-time PCR, vaccine-induced viraemia and faecal shedding occurred at higher loads for CPV-2b than for CPV-2. Interestingly, while viraemia occurred for more days for CPV-2b (mean 22 days) than CPV-2 (mean 19 days), faecal shedding was observed for a longer period in animals vaccinated against the original type (mean 19 days) than animals vaccinated against its variant (mean 12 days). None of the faecal specimens collected from these animals tested positive for CPV using the in-clinic assay, although viral titres, albeit greatly lower than those observed during infections with the pathogenic virus, reached levels that should be detected by these assays (Decaro et al., 2010, 2013).

Accordingly, negative antigen ELISA results were also obtained from the faeces of dogs inoculated with a CPV-2 vaccine, whereas haemagglutination tested unexpectedly positive on several specimens (Schultz et al., 2008). In contrast, a similar study conducted in FPLV-vaccinated cats showed that some animals had in-clinic assay positive results for a few days after vaccination, even though all kits employed contained CPV instead of FPLV antibodies (Patterson et al., 2007).

Until recently, no study has specifically assessed the duration and extent of MLV faecal shedding in adult dogs. In a paper published recently in *The Veterinary Journal*, Monika Riedl, of the Ludwig Maximilian University of Munich, Germany, and colleagues have tried to fill this gap by evaluating post-vaccination CPV shedding in adult dogs with a history of previous vaccinations (Riedl et al., 2017). An old-type (CPV-2 based) vaccine was administered to 100 dogs, which were then monitored for MLV faecal shedding for 28 days. Surprisingly, 23% of these dogs shed the virus in the faeces, irrespective of the presence of protective CPV antibodies in their sera. Positive real-time PCR results were observed only for a few days and at very low titres; therefore, by using PCR amplification and sequencing of the partial VP2 gene of CPV, the authors were able to characterise the CPV strain shed in only a few faecal samples from vaccinated animals. A more precise virus characterisation could have been obtained by using molecular tools able to identify single nucleotide polymorphisms discriminating the vaccine and field viruses by means of strain-specific minor groove binder probes (Decaro et al., 2006a, 2006b).

Although the shedding was intermittent and occurred generally at very low levels, the vaccine virus contained in some samples was successfully isolated in cell culture, thus accounting for the excretion of infectious virus. However, it was not proven whether this virus was able to immunise in-contact dogs. Unfortunately, antigen ELISA testing was not performed on these samples, so that the potential interference of post-vaccination virus shedding with CPV in-clinic assays was not ruled out definitively.

Even dogs with protective antibodies against CPV shed the virus after vaccination, which was unexpected based on our current knowledge of CPV infection. Another striking finding of the same study

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was the detection of low amounts of CPV field strains in the faeces of adult dogs without clinical signs and with protective antibody titres (Riedl et al., 2017). The authors hypothesise that there may be no direct correlation between systemic and local immunity, so that partial replication (of either field or vaccine CPV strains) can occur in the intestinal epithelium even in the presence of high titre serum antibodies. Altogether, these findings imply the need to revisit CPV epidemiology, pathogenesis and prophylaxis. Further studies are required to investigate the correlation between CPV immune status, active infection and faecal shedding in more depth.

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