INTRODUCTION

Canine parvovirus-2 (CPV-2) emerged in 1978 as the etiological agent of haemorrhagic gastroenteritis of dogs characterized by loss of appetite, vomiting and leucopenia (Appel et al., 1979). The disease condition has been dreadful further due to emergence of a number of variants namely CPV-2a, CPV-2b, CPV-2c, New CPV-2a, New CPV-2b and involvement of domestic and wild canines. The prevalence of CPV-2a and New CPV-2a has been documented in Southern India. In North India, the prevalence of CPV-2b is more compared to the other mutants. Occurrence of CPV-2c was first reported in India based on the sequence analysis of a CPV-2b positive sample. Its antigenicity of the CPV variants as it is located in the presence in India supports the assumption that CPV-2c is going to reach a worldwide distribution and provides new information to understand the evolution of antigenic used for the detection of some of the mutants of CPV-2. In parvoviral gastroenteritis cases, conventional live attentu-
uated vaccines are being used to vaccinate small animals. This article is aimed to provide detailed information about different causes of vaccine failure and the best ways to control the disease.

**INDIAN SCENARIO**

In India, the first report of occurrence of CPV-2 dates back to 1982 by Ramadass and Khader, (1982). Since then, the incidence of CPV-2 variants in dogs were reported from different states viz. Kerala, Orissa, Assam, West Bengal, Tamil Nadu, Pondicherry, Haryana and Uttar Pradesh. Occurrence of CPV-2c was first reported in India based on the sequence analysis of a CPV-2b positive sample by Nandi et al. (2010). Later, the outbreak of CPV-2c in vaccinated dogs in Anand district of Gujarat was reported by Gauri and colleagues in 2013.

**CROSS PROTECTION AMONG CPV-2 VARIANTS**

With an increasing number of cases of the current vaccines against this mutant is another question that must be addressed. In an experimental study, using the Neutralization test, the pups inoculated with CPV-2 had antibody titers, which were approximately 30 times higher to homologous virus than to heterologous virus (CPV-2 b). There is only one report which shows of sick dogs showing symptoms suggestive of CPV, including vaccinated animals, raises concerns among breeders, owners and veterinary practitioners about the ability of the current vaccines to protect the pups, as noted previously in other countries (Decaro et al., 2008) The efficiency complete protection against type 2c by an attenuated vaccine based on other CPV type. On the other hand, there are several works reporting vaccine failures when the challenge virus is of the type 2c (Decaro et al., 2008). In order to obtain better protection against the field strains of CPV, the incorporation of a specific new variant of CPV-2 in the vaccine is recommended based on the prevalence in the country.

**CANINE PARVOVIRUS VACCINES**

Initially, killed CPV vaccine was used and in recently modified live vaccine have been developed in search of improved potency. Inactivated vaccines, however, provide only a short immunity to the infection. Although dogs may be protected for several months against disease, they may have subclinical infection. Modified live vaccine offers a longer duration of immunity than killed vaccine. Vaccination of dogs is generally performed using multivalent vaccines, which contain CDV, CPV, leptospira bacteria and inactivated rabies virus. Monovalent CPV-2 vaccines are also available, some of them containing very high titer virus (10^7 TCID50) and widely recommended for initial vaccination of pups.

**CAUSES OF VACCINATION FAILURE**

1) Improper vaccination schedule by pet owners

2) Mismatching of vaccine strain with field strain prevailing in the outbreak area.

3) Interfering level of maternally derived antibodies

4) Allowing the pet with stray dog

5) Lack of disinfection in the premises

6) Lack of awareness of vaccination

7) Importing of dog lacking vaccination history.

Strategies for reducing/overcoming risk of maternal interference include biweekly vaccination and low passage, high titer vaccines.

**CURRENT VACCINES AVAILABLE IN INDIA**

Manufacturers of the vaccine puppy shot are commonly used including:

1) Nobivac DHPPi and Nobivac® Puppy DP Vaccine-strain C 154

2) CANIGEN DHPPi/L Vaccine –Cornell strain

3) Mega Vac-6 Vaccine – Attenuated Parvovirus of canine origin.

**ALTERNATE VACCINES**

**Recombinant vaccine**

Recombinant vaccine containing the baculo virus expressed VP2 protein was found to be structurally and immunologically indistinguishable from authentic. Recombinant VP2 also shows the capability to self assemble, forming virus-like particles similar in size and appearance to CPV virions. The use of these VLPs as vaccines, doses containing only 10 ug of protein were able to elicit neutralizing antibodies and IHA titers sufficient to render all of the immunized animals protected. VP2 is the main determinant of the neutralization-specific immune response in CPV and that it is able to induce protection (Jose et al., 1992).

**DNA vaccine**

Recombinant plasmid pTargeT.cpv2 was used to transfect CRFK cells and found to express VP2 protein as detected by immuno peroxidase test. It was used as DNA vaccine in dog by injecting as 100 ug DNA with and without adjuvant. Continuous expression of CPV viral antigen that is characteristic of DNA vaccine results in better immune response than recombinant vaccine, which delivers only a single pulse of antigen and requires multiple doses to achieve protection and expresses the entire antigenic viral protein in its native form, thus providing better stimulation of the immune system (Gupta et al., 2005).

**Peptide vaccine**

A vaccine dose contained a mixture of 1 mg of peptide IL15 and 1 mg of peptide 7L15, were used (Langeveld et al., 1994). An advantage of the peptide vaccine is the possibility of designing tests, which discriminate between vaccinated and infected animals. With the HI test, animals, which had been infected with virus, could be distinguished from vaccinated animals before experimental infection. Al-
ternative tests could obviously be developed, as is evident from the blocking experiments, in which antibody binding could be inhibited by the peptides used for vaccination only in the sera taken before sero conversion. Such discriminatory tests are useful in programs to eradicate pathogenic viruses like that applied with the veterinary marker vaccine for pseudo rabies virus infection in swine. They can also be of importance in the surveillance of the occurrence of a virus, for which vaccination with peptides might become available.

CONCLUSIONS

Incorporating the field strains in the vaccines will help in conferring complete protection in canines and alternate vaccines using recombinant technology has to be developed apart from conventional vaccines to overcome the emergence of new variants and to reduce the vaccine failure.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

AUTHORS CONTRIBUTION

All authors contributed equally.

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