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OVERVIEW OF THE *CANINE PARVOVIRUS* TYPE 2: ETIOLOGY, PATHOGENESIS, DIAGNOSIS, TREATMENT, AND PREVENTION

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Abstract – *Parvo in dogs is caused by canine parvovirus type 2 (CPV-2), a highly contagious viral disease in dogs that often causes high mortality and is mainly transmitted through the gastrointestinal tract. Nowadays, the variants identified include CPV-2a, CPV-2b, and CPV-2c. This pathogen has appeared in most countries around the world, including Vietnam. Its host range varies with each type of variant, and its relative frequency and genetic variability also vary between countries. The research provides an overview of key information regarding the molecular structure, origin, evolution, and pathophysiology of CPV-2, drawing on 30 published study results from various countries worldwide. This paper helps to identify risk factors that contribute to CPV-2 disease. In addition, the research also synthesizes research on advanced diagnosis, treatment, and CPV-2 vaccine development, serving as a basis for veterinarians, veterinary students, and breeders to control and limit the impact of upper enteritis caused by CPV-2.*

Keywords: Canine parvovirus, diagnosis, etiology, pathogenesis.

I. INTRODUCTION

Canine parvovirus 1 (CPV-1) is often called the canine small virus and is not genetically related to *canine parvovirus 2* (CPV-2), which is one of the primary pathogens causing gastroenteritis. CPV-2 is a non-enveloped virus with a 20-sided capsid and contains single-stranded DNA. The primary capsid protein, VP2, defines the virus of the antigenic group. CPV-2 evolved from *feline panleukopenia virus* (FPV). CPV-2 can induce myocarditis and acute hemorrhagic enteritis in dogs and puppies. It is the most deadly and extremely contagious disease for puppies aged up to six months [1]. After CPV was initially identified in 1978, three varieties (CPV-2a, CPV-2b, and CPV-2c) were produced through genetic mutation. Worldwide distribution of CPV-2 and its variants has been documented in the United States, the United Kingdom, Brazil, Japan, Switzerland, and South Africa [2]. CPV-2 primarily manifests as hemorrhagic diarrhea and, in rare instances, myocarditis [3]. Vaccinated dogs were also found to be infected with CPV-2. This virus is very contagious and can spread through contaminated food or drink that comes from excrement or other things. Clinical signs of CPV-2 illness are frequently nonspecific, with signs of despair, lethargy, and fever. After 24 hours of infection, the dog vomits and has bloody diarrhea, causing severe dehydration. It is vital to identify CPV-2 to stop the disease's early progression. CPV-2 detection relies mostly on molecular and immunological approaches [4]. To control *parvovirus* disease, several types of vaccines have been studied, including inactivated vaccines and modified live vaccines [4]. The most common causes of vaccine failure are interaction with maternally produced antibodies, inappropriate vaccination timing, and, in rare cases, viral vaccine reversion [5]. Although many different medications have been tested and used to treat dogs with CPV, they are expensive and scarce on the market [6]. However, to control and manage the CPV-2 infection, additional advancements are required in diagnostics and pre- and post-infection treatment. By combining and evaluating thirty study findings that have been disseminated globally, this review will provide a

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brief and basic overview of *canine parvovirus*, including etiology, pathogenesis, treatment options, and prevention measures. Furthermore, this may be an area of interest for veterinary professionals, faculty, and veterinary students to limit disease outbreaks due to CPV-2.

II. RESEARCH CONTENTS

A. *Etiology*

Classification

Parvovirus is a small virus, belonging to the *Paraviridae* family. The *Paraviridae* family is divided into two subfamilies: *Parvovirinae* and *Densovirinae*. *Parvovirinae* includes viruses that cause disease in vertebrates, and Densovirinae includes viruses that cause disease in insects. In the *Parvovirinae* subfamily, there are three genera, including, first, the *Parvovirus* genus, which infects vertebrates and replicates automatically in the body without catalyst; second, the Erythrovirus genus, which mainly infects humans; and the rest, the *Dependovirus* genus, which includes viruses related to *Adenovirus* (adeno-associated viruses), which have defective structures and are unable to replicate [7]. CPV in dogs has two main types: CPV-1 and CPV-2. CPV-1 causes acute enteritis in dogs and is considered related to *bovine parvovirus* (BPV) [8] (Figure 1). To date, no variants of CPV-1 have been reported [9].

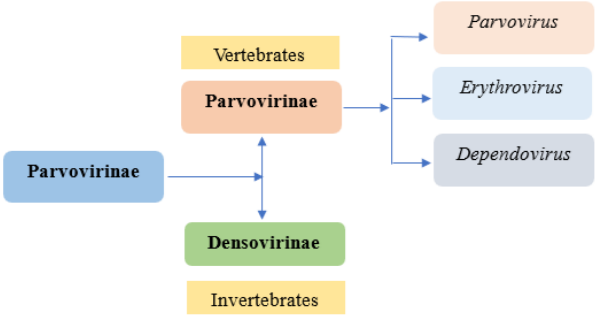

Fig. 1: *Parvovirinae* classification scheme [9]

Structure

The single-stranded DNA genome of CPV - 2, which contains two open reading frames (ORFs) to code for three structural proteins (VP1, VP2, and VP3) as well as two non–structural proteins (NS–1 and NS–2) [7]. The whole VP2 sequence and an additional N–N-terminal segment are presented in VP1. CPV-2 is an icosahedron–shaped, non–enveloped virus with a diameter of 25 nm [10]. The 60 protein subunits that comprise the capsid share a common structure and are organized with T = 1 icosahedral symmetry. Of these, approximately 5–6 copies of VP1 and 54–55 copies of VP2 are presented. VP2 is a key determinant of host range and virus-host interactions and is cleaved into VP3 by host proteases. A 22 Å long elevated section (apex) on the threefold axis, a 15 Å deep depression (canyon) around cylindrical structures on the fivefold axes, and a 15 Å deep depression (dimples) at the double axes are some of the capsids of surface features. The trifold axes are also the most antigen–rich areas of the capsid, making them targets for antibodies that neutralize them [11]. The genetic structure of CPV-2 is shown in Figure 2.

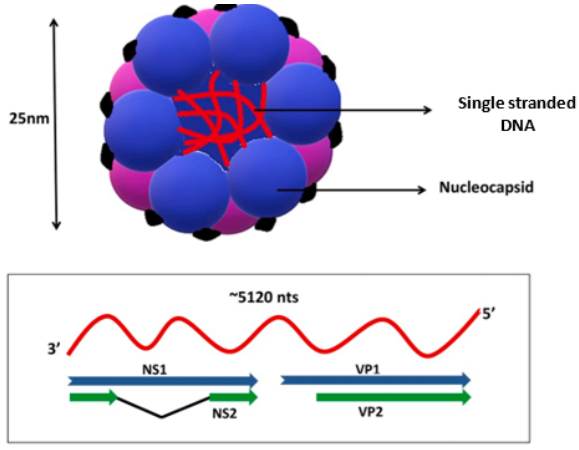

Fig. 2: Genetic structure of CPV-2 [9]

Origin and evolution of CPV-2

VP2 makes up 90% of the CPV-2 capsid, which controls the host range, antigenicity, and tissue-specificity of the virus [7]. Although FPV and CPV-2 are known to be closely related, there are six amino acid differences between them in VP2. This difference is caused by amino acid changes in VP2 and allows CPV-2 to increase

its affinity for transferrin receptors (TfR) in dogs [12]. After first emerging in America, Japan, Belgium, Australia, and other countries, the CPV-2 strain eventually took over continents. In 1980, CPV-2a completely replaced CPV-2 and was present on all continents due to mutations in some amino acid positions in VP2. These changes enable CPV-2 to bind to the feline TfR [4]. This indicated the superiority of the CPV-2a variant over CPV-2 in terms of epidemiology and higher affinity for canine cell receptors. Then, an amino acid at position 426 of CPV-2a was mutated, and immediately the CPV-2b variant was born (1984). Also at position 426, a second change created CPV-2c and was discovered in Germany in 1996 [4]. Some mutations were small enough to produce novel changes that are relevant to epidemiology. Amino acid substitution at position 297 occurs simultaneously in CPV-2a and CPV-2b. These alterations did not affect the variations' antigenicity because they were positioned at the secondary antigen site (epitope B). Mutations at amino acid position 440 (Thr to Ala) have occurred in some variants, and this change may affect the properties of the antigen. There is a substitution at position 324 (Tyr to Ile) of VP2 that affects the host range [2]. The emergence of opportunistic bacteria has occurred in several cases of CPV-2 infection [13]. In one example, dogs with CPV-2a are shown to have 29 nucleotides different from CPV-2c. By 2000, this variant had caused an outbreak in Italy. Additionally, dogs are infected with recombined variants of CPV-2a and CPV-2c. These incidents reflect the viral variety and the introduction of novel CPV-2 genotypes (2). However, antigenic variability is also associated with adaptive capacity, phenotypic characteristics, and epidemiological advantages among CPV-2 variants [14]. Infection is known to occur on five continents throughout the world. The genetic development of CPV-2 is seen in Figure 3.

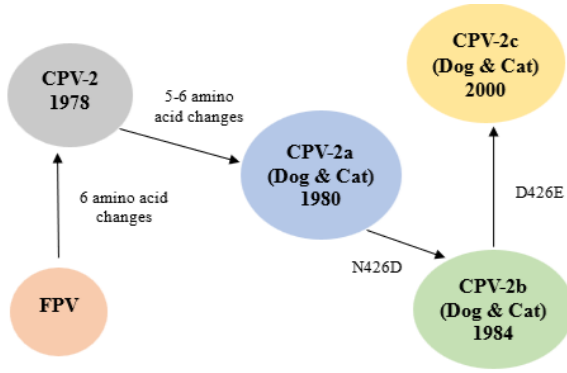

Fig. 3: Canine parvovirus evolution diagram from 1978 to 2000 [2]

B. Pathogenesis

The most common way to become infected with CPV-2 is through feces or coming into touch with polluted surfaces [8]. In cages, dogs infected with CPV-2 excrete substances that can make other dogs susceptible to infection. CPV-2 is attracted to cells that divide quickly. It replicates in lymphocytes after first invading the pharynx. A few days later, the virus breaks loose in the bloodstream and makes its way into the bone marrow, where it targets the white blood cells and induces a severe case of leukopenia. Within five days of invading lymphoid tissue, it causes viremia [14, 15]. If puppies are born to unvaccinated mothers with CPV-2 disease, the virus will replicate in the myocardium during the first two weeks of infection. Cardiac manifestation of the virus is uncommon since most puppies obtain maternal-derived antibodies (MDA), which protect the neonate. Once the virus has spread from infected leukocytes, it reaches the germinal epithelium of the small intestine's crypts, causing diarrhea. Intestinal epithelial cells mature in Lieberkuhn crypts and move from the germinal epithelium to the villi. The role of these primary cells is to help in the absorption of nutrients. The virus affects Lieberkuhn's crypts, causing a villous collapse [9, 16]. The turnover of these quickly dividing intestinal crypts is disrupted, resulting in distinctive lesions and affecting intestinal absorption ability. Both blood lymphocytes and intestinal tissue are infected, leading to lymphocytopenia and neutropenia. Dogs infected with CPV-2 are susceptible to secondary bacterial infections. The

destruction of villi, inflammation, and necrosis lead to an imbalance of the intestinal microflora and sepsis. After 4–7 days of infection, dogs begin to shed detectable amounts of virus particles [9, 17].

C. Clinical symptoms

Infected dogs with CPV-2 develop fever gradually at first, followed by vomiting and diarrhea as the infection progresses. Stool consistency changes and is yellow or may contain blood. After infection, clinical symptoms usually appear three to five days later and persist for five to seven days [18]. Loss of appetite, lethargy, exhaustion, copious or bloody diarrhea, stomach pain, fever, dehydration, and, in the worst situations, death are the clinical signs linked to infected dogs [9]. Leukopenia may result from a white blood cell count that is less than 2000–3000 cells/ml [13]. The duration of infection is determined by the amount of virus entering the body of dogs. Dogs with CPV-2 infection have varying rates of mortality and morbidity depending on the severity of the disease, the age of the animal, and co-infection with other diseases [19]. In cases of co-infection, the virus damages the intestines and speeds up the flow of bacteria through the blood, resulting in septicemia, endotoxemia, coagulopathy, systemic inflammation, and septic shock. In some cases, E. coli bacteria have been discovered in the lungs and liver of infected puppies. Frequently, lung infections result in respiratory failure [19]. Myocarditis is a rare clinical symptom of CPV-2 infection in puppies under the age of three months. Puppies experience agonal breathing after prolonged infections. Puppies with minor infections are routinely treated as outpatients [14]. In most cases, outpatient care is not suggested because pet owners frequently fail to deliver oral treatment on time. As a result, the health of puppies deteriorated due to acute vomiting.

D. Diagnostics

Examining clinical symptoms (such as lethargy, vomiting, diarrhea, anorexia, and fever) and immunization history are the primary methods used in the preliminary diagnosis of CPV-2. The vital signs of sick dogs, including dehydration, exhaustion, abdominal pain, heart rate, and rectum, are examined by veterinarians. In addition, tests are performed on other variables such as blood gas analysis, glucose level, electrolyte assessment, WBC count, serum biochemistry, and urine analysis [13, 17]. Clinical symptoms and physical examinations, on the other hand, are regarded as a presumptive diagnosis of the condition and are not always valid in case studies [17].

Traditional methods

Traditional tests include viral antigen detection tests, electron microscopes, and immunochromatography (IC). However, these tests are not highly sensitive and cost a lot of money, time, effort, and cost. Therefore, these tests are rarely used.

- Virus isolation (VI)

The gold standard for diagnosis is virus isolation through cell culture methods. To create a single cell layer, people multiply cell lines in culture. After the virus suspension underwent titer testing, a single cell layer was plated [20]. It has been noted that CPV-2 replicates in cell lines from cats and dogs. Therefore, in a number of studies isolating CPV-2 from dog lung and kidney cells, the results showed that the virus is capable of creating typical effects of pathogenic cells such as cell sloughing, cell shape changes, and inclusions appearing in the host cell nucleus [21]. Although virus isolation and culture are thought to be very specific, they are expensive, time-consuming, and labor-intensive processes [13].

- Hemagglutination assay (HA)

Viral tittering by HA is predicated on the virus's capacity to bind to RBCs (red blood cells) surface receptors and cause virus agglutination. The viral suspension is serially diluted and titrated with a fixed quantity of red blood cells to conduct the test [19]. The main cell receptor for CPV-2 is the transferrin receptor; however, it can also hemagglutinate RBCs. The CPV-2 virus has been demonstrated to interact

with and bind to the sialic acid receptor, as well as agglutinate RBCs. VP2 capsids allow hemagglutination to occur at pH = 8. A temperature of 4^oC is the optimal condition for hemagglutination and the hemagglutination assay can use red blood cells from goats, dogs, and pigs. For these tests, three different buffer systems were utilized, including phosphate buffer with bovine serum albumin (BSA) (15 mM containing 0.1% BSA), phosphate-buffered saline (15 mM PBS containing 0.9% NSS), and normal saline solution (0.9% NSS). Inadequate handling and preservation of red blood cells can impact the sensitivity of the assay. Furthermore, a changed erythrocyte sedimentation coefficient can impact the HA [21].

Molecular methods

One of the most cutting-edge molecular tools for identifying various illnesses is real-time polymerase chain reaction (RT-PCR). The RT-PCR-based test is much quicker than conventional PCR since it combines PCR with a fluorescent probe to detect the target gene in an hour or less. The test yields result in real-time and can be used for both qualitative and quantitative research. One benefit of RT-PCR is that it does not require analysis based on gel electrophoresis. To conduct the test, though, calls for specialized laboratories and is quite costly [22]. A combinatorial method based on mini sequencing and RT-PCR is developed to identify and separate three CPV-2 variants. The investigation employed mini sequencing after SYBR green-based RT-PCR to distinguish between the variants. Using sets of primers with a single baseless known single nucleotide polymorphism (SNP) at the 3' ends of each primer, the mini-sequencing method is utilized. Fluorescence-labeled dNTPs were added after primer annealing, and then polymerase was used to extend the strand. The additional nucleotide was subsequently detected, revealing the SNP located at that site [23]. A real-time minor groove binding assay (MGB) was designed to differentiate between CPV-2 variants. The experiment employed highly specific probes that could bind to the target of interest for amplification for each type of antigen. Moreover, RT-PCR was used to measure the fluorescence [24].

E. Treatment of CPV-2 infection in canines

The speed at which canine parvovirus is identified, the dog's age, and the severity of the treatment all affect survival chances. Dogs with CPV-2 enteritides frequently die from it, especially puppies [18]. This illness does not have a particular therapy. Veterinarians frequently combine various strategies, including food control, vitamins, antiemetics, and antibiotics.

Fluid therapy

Patients infected with CPV-2 frequently experience fluid loss because of severe diarrhea, which can be managed with fluid treatments. Sick dogs with severe vomiting or diarrhea need to be given an equivalent amount of fluid intravenously to fully rehydrate. The amount of fluid given to sick dogs depends on their body weight and degree of dehydration [13]. The infusion fluid commonly used to rehydrate and electrolytes is glucose and Ringer's lactate at a dose of 7 - 12 ml/kg body weight, intravenously infused for 24 hours. In cases where intravenous infusion is not possible, it can be given through the subcutaneous route. Anti-vomiting with Primperan, reducing intestinal motility with Atropine sulfate at a dose of 0.1 mg/kg body weight injected under the skin, stopping bleeding with vitamin K, and using broad-spectrum antibiotics to prevent secondary infections will help the dog recover quickly from the disease [6, 17].

Hypoalbuminemia or hypoproteinemia can result from protein loss because dogs infected with parvovirus frequently develop intestinal inflammation. Diarrhea that is bloody causes significant blood loss. To keep the intravascular osmotic pressure constant, a synthetic substance like hetastarch 6% should be utilized [20]. For this reason, blood transfusions are advised for anemic dogs. Clinical indicators of anemia should be the basis for transfusion decisions [6].

Antibiotic treatments

Patients infected with CPV-2 frequently develop bacterial co-infections because of the loss

of gastrointestinal epithelial cells, which causes continual bacterial translocation, leading to sepsis and endotoxemia. It is advised to treat the illness with a mix of β-lactam antibiotics, such as ampicillin or cefazolin, and aminoglycosides, such as gentamicin [22]. It is not advised to provide large dosages of aminoglycosides to dehydrated dogs. Enrofloxacin is an additional fluoroquinolone that exhibits efficacy against Gram-negative bacteria. Metronidazole is an injectable antibiotic that targets anaerobic bacteria. Using antibiotics to treat minor infections in dogs is not advised [6, 16].

Antiemetic treatment

Metoclopramide and chlorpromazine are two antiemetic medications that can be used to treat vomiting, which is one of the most prevalent symptoms of CPV-2 enteritis. A dopamine antagonist called metoclopramide increases gastrointestinal motility and inhibits the part of the brain that triggers nausea. For dogs who could develop intussusception, it is not regarded as safe. It may occasionally result in tremors and muscle fasciculations. Chlorpromazine, an intravenous phenothiazine derivative that blocks dopamine receptors in the brain, is commonly administered to dogs with CPV-2 [6]. Other antiemetic medicines that are advised include maropitant, ondansetron, and dolasetron [13]. Metoclopramide is thought to be less effective as an antiemetic than ondansetron [25].

Dietary management

Nil pros (NPO) can be used to treat osmotic diarrhea in CPV-2 dogs for a duration of six to twelve hours. Then, by improving the health of the intestinal mucosa, dosages of glucose, isotonic solutions, and hydrolyzed protein can be given to dramatically reduce diarrhea [13]. Reduced bacterial and endotoxin translocation with early enteral feeding lowers the risk of coliform septicemia. The amount of gastric residual volume is one factor that affects enteral nutrition. Nasogastric or oesophagogastric tubes can be used to deliver complex nutritional formulas. Peripheral intravenous products such as procalamine can be used to provide partial parenteral nutrition to severely debilitated dogs [22]. An infected dog may get multiple oral recuperation fluids (ORF) to increase calorie intake and voluntary appetite. The contents of ORF include probiotics, omega fatty acids, and critical amino acids including taurine, arginine, and glutamine. These nutrients promote healing and maintain the integrity of the gastrointestinal tract [26]. Fecal bacteria transfer (FMT) is a means of reestablishing the intestinal microbiota of dogs suffering from CPV-2 enteritis. In other words, people feed dogs with CPV-2 by using the excrement of healthy dogs [26].

F. Prevention

A pathogen called CPV-2 causes enteritis in dogs, spreading quickly and having a high fatality rate in tiny dogs [27]. Preventing CPV-2 illness is so crucial. Families that raise dogs, dog farms, and vet clinics all need to be very mindful of the well-being of their dogs. The best way to protect dogs from the risk of infection is to vaccinate them completely and regularly. Sick dogs and their excrement should be kept apart from healthy dogs. Barns and cages should also be cleaned and disinfected frequently to prevent the spread of infections [10, 14]. Additionally, to boost resistance and stop the spread of CPV-2 sickness, animals require a certain diet and set of care guidelines [27].

Vaccine-based prevention of CPV-2 disease is a top priority. Therefore, there are many types of vaccines being researched and developed against CPV-2, most of which are modified live virus (MLV) vaccines and a few inactivated vaccines. Some vaccines are using the CPV-2b strain, while others still use the original CPV-2 strain [28]. Recombinant vaccines based on virus-like particles (VLPs) are also being developed. The advantage of these vaccines is that they have high immunogenicity and high safety [29]. However, vaccination failure also often occurs, mainly due to the influence of natural antibodies originating from the mother. In addition, other secondary causes include vaccine storage, vaccination errors, animal age, and immune status [30].

III. CONCLUSION

The success of studies on CPV-2 causing enteritis in dogs has resulted in substantial advances in disease prevention and dog health protection around the world. Research on the biological characteristics of the virus has explained the mechanism by which CPV-2 interacts with host cells and the mechanisms of its spread. This has made it possible to develop more precise and efficient diagnostic techniques, which will aid in the early detection and timely treatment of CPV-2 cases. The identification of different variants of CPV-2, such as CPV-2a, CPV-2b, and CPV-2c, as well as their evolution from FPV has provided important information for developing many types of vaccines and more effective treatment methods. The molecular and immunological-based assays used in current CPV-2 diagnostic procedures enable quick and precise virus detection. This is a significant advancement in the fight against the disease since it will lessen its harmful effects and stop its spread in dogs, particularly puppies. Treatments have been developed and improved, including fluid therapy, antibiotics, and supportive therapy. These methods help relieve symptoms, prevent serious complications, and increase the chance of survival for dogs infected with CPV-2. In addition, the development and widespread application of CPV-2 vaccines have significantly contributed to reducing the incidence of the disease. Continuous research on the biological structure and variations of CPV-2 helps update and improve the effectiveness of vaccines, protecting the health of dogs in a sustainable and long-term way. In summary, advances in CPV-2 research have brought about outstanding achievements in protecting the health of pet dogs and affirming the important role of science and technology in dealing with infectious diseases.

REFERENCES

[1] Black JW, Holscher MA, Powell HS, Byerly CS. Parvoviral enteritis and panleukopenia in dogs. *Veterinary Medicine & Small Animal Clinician*. 1979:74(1): 47–50.

[2] Miranda C, Thompson G. Canine parvovirus: the worldwide occurrence of antigenic variants. *Journal of General Virology*. 2016;97(9): 2043–2057. http://doi.org/10.1099/jgv.0.000540.

[3] Tavora F, Gonzalez-Cuyar LF, Dalal JS, O'Malley MT, Zhao R, Peng HQ, et al. Fatal parvoviral myocarditis: A case report and review of the literature. *Diagnostic Pathology*. 2008;3(1): 1–6. http://doi.org/10.1186/1746-1596-3-21.

[4] Nandi S, Kumar M, Mohapatra TK, Ravishankar C. Emergence of canine parvovirus-2 variants and its impact on vaccination. *World Applied Sciences Journal*. 2013;23(10): 1366–1376.

[5] Bull JJ. Evolutionary reversion of live viral vaccines: Can genetic engineering subdue it? *Virus Evolution*. 2015;1(1): 1–10. https://doi.org/10.1093/ve/vev005.

[6] Mylonakis M, Kalli I, Rallis T. Canine parvoviral enteritis: an update on the clinical diagnosis, treatment, and prevention. *Veterinary Medicine: Research and Reports*. 2016;7: 91–100. http://doi.org/10.2147/VMRR.S80971.

[7] Nelson CDS, Minkkinen E, Bergkvist M, Hoelzer K, Fisher M, Bothner B, et al. Detecting small changes and additional peptides in the canine parvovirus capsid structure. *Journal of Virology*. 2008;82(21): 10397–10407. http://doi.org/10.1128/JVI.00972-08.

[8] Tagorti G. Prevalence of canine parvovirus infection in Grand Tunis, Tunisia. *Journal of Advanced Veterinary and Animal Research*. 2018;5(1): 93–97. http://doi.org/10.5455/javar.2018.e251.

[9] Ogbu KI, Anene BM, Nweze NE, Okoro JI, Danladi MMA, Ochai SO. Canine parvovirus: a review. *International Journal of Science and Applied Research*. 2017;2(2): 74–95.

[10] Callaway HM, Feng KH, Lee DW, Allison AB, Pinard M, McKenna R, et al. Sandri-Goldin RM (eds.). Parvovirus capsid structures required for infection: mutations controlling receptor recognition and protease cleavages. *Journal of Virology*. 2017;91(2): 1–16. http://doi.org/10.1128/JVI.01871-16.

[11] Kang JI, Park NY, Cho HS. Detection of canine parvovirus in fecal samples using loop-mediated isothermal amplification. *Journal of Veterinary Diagnostic Investigation*. 2006;18(1): 81–84. http://doi.org/10.1177/104063870601800111.

[12] Truyen U. Evolution of canine parvovirus – A need for new vaccines? *Veterinary Microbiology*. 2006;117(1): 9–13. http://doi.org/10.1016/j.vetmic.2006.04.003.

[13] Decaro N, Buonavoglia C. Canine parvovirus—a review of epidemiological and diagnostic aspects, with emphasis on type 2c. *Veterinary Microbiology*. 2012;155(1): 1–12. https://doi.org/10.1016/j.vetmic.2011.09.007.

[14] Ford J, McEndaffer L, Renshaw R, Molesan A, Kelly K. Parvovirus infection is associated

with myocarditis and myocardial fibrosis in young dogs. *Veterinary Pathology*. 2017;54(6): 964–971. http://doi.org/10.1177/0300985817725387.

[15] Geetha M. Epidemiology, pathogenesis, clinical findings and diagnosis of canine parvo viral infection–a mini review. *International Journal of Scientific Engineering and Applied Science*. 2015;1(9): 21–27.

[16] Tuteja D, Banu K, Mondal B. Canine parvovirology–A brief updated review on structural biology, occurrence, pathogenesis, clinical diagnosis, treatment and prevention. *Comparative Immunology, Microbiology and Infectious Diseases*. 2022;82: 101765. http://doi.org/10.1016/j.cimid.2022.101765.

[17] Prittie J. Canine parvoviral enteritis: A review of diagnosis, management, and prevention. *Journal of Veterinary Emergency and Critical Care*. 2004;14(3): 167–176. http://doi.org/10.1111/j.1534-6935.2004.04020.x.

[18] Nandi S, Kumar M. Canine Parvovirus: current perspective. *Indian Journal of Virology*. 2010;21(1): 31–44. http://doi.org/10.1007/s13337-010-0007-y.

[19] Sharma S, Dhar P, Sharma M. Study of different risk factors for canine parvovirus infection by haemagglutination assay. *Journal of Animal Research*. 2019;9(5): 735–739.

[20] Hematian A, Sadeghifard N, Mohebi R, Taherikalani M, Nasrolahi A, Amraei M, et al. Traditional and modern cell culture in virus diagnosis. *Osong Public Health and Research Perspectives*. 2016;7(2): 77–82. https://doi.org/10.1016/j.phrp.2015.11.011.

[21] Lambe U, Guray M, Bansal N, Kumar P, Joshi VG, Khatri R, et al. Canine parvovirus-an insight into diagnostic aspect. *Journal of Experimental Biology and Agricultural Sciences*. 2016;4(3S): 279–290. http://dx.doi.org/10.18006/2016.4(3S).279.290.

[22] Van Schoor M, Schoeman JP. Early enteral nutrition in puppies with parvovirus enteritis. *Vet Nurse*. 2014;5(8): 434–440. http://doi.org/10.12968/vetn.2014.5.8.434.

[23] Gonuguntla HN, Surendra K, Rana SK, Ponnanna NM, Subramanian BM, Sharma GK, et al. Detection and typing of CPV with real-time PCR and mini sequencing. *Advances in Animal and Veterinary Sciences*. 2016;4(4): 187–194. http://dx.doi.org/10.14737/journal.aavs/2016/4.4.187.194.

[24] Wang J, Liu L, Li R, Wang J, Fu Q, Yuan W. Rapid and sensitive detection of canine parvovirus type 2 by recombinase polymerase amplification. *Archives of Virology*. 2016;161(4): 1015–1018. http://doi.org/10.1007/s00705-015-2738-y.

[25] Rerksuppaphol S, Rerksuppaphol L. Efficacy of intravenous ondansetron to prevent vomiting episodes in acute gastroenteritis: a randomized, double blind, and controlled trial. *Pediatric Reports*. 2010;2(2): 55–57. https://doi.org/10.4081/pr.2010.e17.

[26] Tenne R, Sullivan LA, Contreras ET, Olea-Popelka F, Twedt DC, Fankhauser J, et al. Palatability and clinical effects of an oral recuperation fluid during the recovery of dogs with suspected parvoviral enteritis. *Topics in Companion Animal Medicine*. 2016;31(2): 68–72. https://doi.org/10.1053/j.tcam.2016.08.001.

[27] Kilian E, Suchodolski JS, Hartmann K, Mueller RS, Wess G, Unterer S. Long-term effects of canine parvovirus infection in dogs. *PloS One*. 2018;13(3): 1–11. https://doi.org/10.1371/journal.pone.0192198.

[28] Vasu J, Srinivas MV, Antony PX, Thanislass J, Padmanaban V, Mukhopadhyay HK. Comparative immune responses of pups following modified live virus vaccinations against canine parvovirus. *Veterinary World*. 2019;12(9): 1422–1427. http://doi.org/10.14202/vetworld.2019.1422-1427.

[29] Decaro N, Buonavoglia C, Barrs VR. Canine parvovirus vaccination and immunisation failures: Are we far from disease eradication? *Veterinary Microbiology*. 2020;247: 108760. https://doi.org/10.1016/j.vetmic.2020.108760.

[30] Hao X, Li Y, Xiao X, Chen B, Zhou P, Li S. The changes in canine parvovirus variants over the years. *International Journal of Molecular Sciences*. 2022;23(19): 11540. http://doi.org/10.3390/ijms231911540/.