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Epidemiological Observation on Recent Outbreaks of Canine Parvoviral Enteritis in Korea

Seok-Young Jeoung, Doo Kim[1], So-Jeo Ahn and Son-Il Pak

School of Veterinary Medicine, Kangwon National University, Chunchon 200-701, Korea

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Abstract : Recently canine parvovirus (CPV) enteritis had been controlled successfully by the use of low-passage high titer modified live CPV vaccines. However, outbreaks of CPV enteritis have been continued in Korea. In this study, we carried out epidemiological investigation on the recent outbreaks of CPV enteritis of dogs and determined the potential prognostic factors affecting the survival of dogs. The total of 140 dogs diagnosed for CPV enteritis were statistically analysed. The majority of dogs were from 6 to 18 weeks of age and were not vaccinated or incompletely vaccinated. There were significant difference in the survival rate between male and female dogs with CPV enteritis and among the age groups ($P<0.05$). Moreover, there was significant difference in the survival rate of dogs between HI titer <80 group and HI titer 160 group ($P<0.05$). The majority of dogs had a history of diarrhea, vomiting, lethargy and dehydration. It was considered that recent outbreak of CPV enteritis in Korea caused by the failure of vaccination and/or by the inadequate antibody responses to CPV vaccines. Prophylactic measures should include isolation of young dogs from the dog population until the vaccination can be expected to provide protection.

Key words : canine parvovirus, enteritis, epidemiology, Korea.

Introduction

Clinical signs of dogs with enteritis caused by canine parvovirus (CPV) include profuse bloody diarrhea, vomiting, dehydration, abdominal pain, fever, and shock (1,31). Initial outbreaks of parvovirus in dogs were characterized by high morbidity and mortality in all age groups. Currently, the disease is most commonly seen in puppies from 6 weeks to 6 months of age. Most adult dogs have become immune through vaccination or natural infection. This immunity is passed on to newborn puppies via maternal antibodies (2).

CPV type 2 (CPV-2) emerged as a new pathogen of dogs in the late 1970s (21,22), but it was progressively replaced by two new antigenic variants of the virus: CPV type 2a (CPV-2a) in 1980 and CPV type 2b (CPV-2b) in the mid 1980s (28). These new types are distributed worldwide (5,16,26,37) and differ from the original type 2 by amino acid changes affecting the capsid protein and by their extended host range, which includes canine and feline cells in vitro and dogs and cats (19). Subsequently, the emergence of further mutations in the CPV capsid protein has been reported in several countries (3,39).

In pups, maternally-derived antibodies (MDA) represent the main protection against CPV infection, but at the same time they may interfere with CPV vaccination (7,10,15,32). The MDA strongly protects young animals from CPV infection by sequestrating the virus prior the onset of viremia, thus preventing colonization of the intestinal epithelium (32,34). The interference of MDA with the active immunization against CPV has been partially overcome by using high-titer vaccines (17,29,32,36).

The predisposing factors for CPV-2 infection in pups are lack of protective immunity, several diseases, and stressful environmental conditions (4). Certain breeds are reported to be more susceptible to the development of CPV enteritis despite antibody titers considered protective in other breeds (4,14,19). In a seasonal study, incidence peaked of November, December, and January in West German and of June, July, August and September in America and Canada (19,30).

The purpose of the study reported here was to investigate recent outbreaks of CPV enteritis of dogs in Korea on the basis of sex, breed, season, vaccination status, and survival features of infected dogs. And the background factors involved in outbreaks of CPV enteritis were assessed to characterize the recent outbreaks of CPV enteritis.

Materials and Methods

Clinical specimens and data collection

Samples of fecal specimens and peripheral blood from 227 dogs which were clinically suspected for CPV infection were collected by local veterinarians in Kangwon, Kyunggi, Gyeongbuk, and Seoul areas between June, 2003 and May, 2005. Details on the sex, age, season, vaccination status, breed, clinical signs, and prognosis were recorded. Vaccination status

[1]Corresponding author.
E-mail : kimdoo@kangwon.ac.kr

was recorded according to the notification by owner of the patient and divided into three categories; complete vaccination (more than three times vaccination were performed), incomplete vaccination (less than three times vaccination were performed), and none vaccination.

Fecal specimens were taken by swab from the anus of diarrheic dogs and homogenized (10% w/v) in phosphate buffered saline (PBS, pH 7.2). The tentative diagnosis for CPV infection was carried out with a commercial kit (SNAP® Canine Parvovirus Antigen Test, IDEXX Laboratories, Inc., Westbrook, Maine, USA), following the manufacturer's instructions.

Polymerase chain reaction (PCR)

To confirm the CPV infection, the PCR was carried out with a minor modification of our previous protocol (41) to detect VP2 gene from the fecal swab samples. Oligonucleotide primers used for amplification of the CPV VP2 gene sequences were selected from the reference (28,35). One foreword primer was a 20-mer (5'-AAAGAGAGCCAGGAGAGGTA-3') and the other reverse primer was a 22-mer (5'-TTCTGACAGCAGGTTGACCA-3'), located at positions 2,299-2,318 and 2,815-2,834 nucleotides, respectively (17). Positions are indicated according to the positions of Reed *et al* (36), which are available from GenBank-NCBI data bank under accession No. M19296. The expected amplicon length by the primer pair was 536-bp. The virus DNA was extracted using QIAamp DNA mini kit (Qiagen). The PCR condition was denaturation at 94°C for 1 min, annealing at 55°C for 1 min, extension at 72°C for 1 min for 35 cycles. The PCR products were analyzed on a 2% agarose gel after staining with ethidium bromide.

Hemagglutination inhibition (HI) test

Serum CPV antibody titer was determined by the hemagglutination inhibition (HI) test as described by Carmichael *et al* (8), with minor modification. After heat inactivation at 56°C for 30 mins, the sera were treated with pig erythrocytes to remove non-specific inhibitors of viral hemagglutination. Serial two-fold dilutions of the treated sera were prepared in U-bottomed microtiter plates and then an equal volume (50 μl) of virus suspension, containing 8 hemagglutination units of CPV, was added to each well. When the serum-virus mixtures had been incubated for 60 minutes at room temperature, 50 μl of 1 percent pig erythrocytes was added to each well and the plates were kept at 4°C for four hours. The antibody titer was considered to be the reciprocal of the highest dilution that completely inhibited hemagglutination. In each test, known negative and positive sera with moderate and high titers were included. Results were only accepted when the titers of the standard sera fell within specific limits (a two-fold change for the positive sera).

Statistical analysis

A two-tailed Fisher's Exact test or chi-square test of homogeneity was used to evaluate the hypothesis that survival rate was homogeneous among dogs divided by study factors. Data from the whole population were summarized by calculating descriptive statistics. The potential association of age, sex, season, vaccination statues, clinical signs (diarrhea, vomiting, and respiratory signs), and HI titer was evaluated by logistic regression (live=0, death=1) by creating n-1 dummy variables for variables with n levels. All independent variables initially were screened by univariate analysis to assess simple association between dependent and independent variables by unconditional calculating odds ratio (ORs), associated 95% confidence intervals (95% CI), and *P* values. Variables that met a critical *P* value of less than 0.2 in the univariate analysis were included in the multivariate analysis. Selection of variables for multivariable modeling with a forward stepwise analysis was performed as described by Hosmer and Lemeshow (18). The multivariate modeling approach allows to evaluate several factors simultaneously while controlling for potential confounding factors. The Hosmer-Lemeshow statistic was calculated for the final models to evaluate the goodness-of-fit of the data. All analyses were performed using SAS version 9.1 (SAS Institute, Cary, NC). *P* values less than 0.05 were considered statistically significant, if not indicated otherwise.

Results

Distribution of the dogs with CPV enteritis in epidemiological parameters

Among the total of 227 dogs that were clinically suspected for CPV enteritis, 219 dogs were diagnosed as CPV enteritis by PCR. The 140 of these 219 dogs with CPV enteritis were statistically analysed because their vaccination history and other demographic information were available. At the end of the study, 62 dogs (44.3%) survived, 41 (29.3%) dogs died, but prognosis of 27 (19.4%) dogs was not identified. Of these 140 dog, 69 (49.3%) dogs were male and 71 (50.7%) were female. Of the 97 dogs of which sex and prognosis was recorded, 38 of 54 (70.4%) female dogs and 19 of 43 male dogs (44.2%) survived. There was significant difference in the survival rate between male and female dogs with CPV enteritis ($P<0.05$).

The distribution of the dogs with CPV enteritis according to age was shown in Fig 1A. Five (3.9%) of 140 dogs were less than 6 weeks of age, 103 (74.1%) dogs were between 6 and 18 weeks of age, 28 (20.1%) dogs were over 18 and 52 weeks of age, and only 4 (2.9%) dogs were older than 1 year. Overall, 77.7% of the dogs with CPV enteritis were less than 18 weeks of age. There was significant difference in the survival rates among the age groups ($P<0.05$). Of these 41 dogs died, 32 dogs were between 6 and 18 weeks of age, 4 dogs were between 18 and 52 weeks of age, none was over 53 weeks of age. However, all 5 dogs less than 6 weeks of age died.

The most prevalent breed was Cocker Spaniel (17.1%), and then the prevalence followed by Shih-tzu (14.3%), Alaskan Malamut (8.6%), Toy Poodle (7.9%), Jindo (7.1%), Maltess

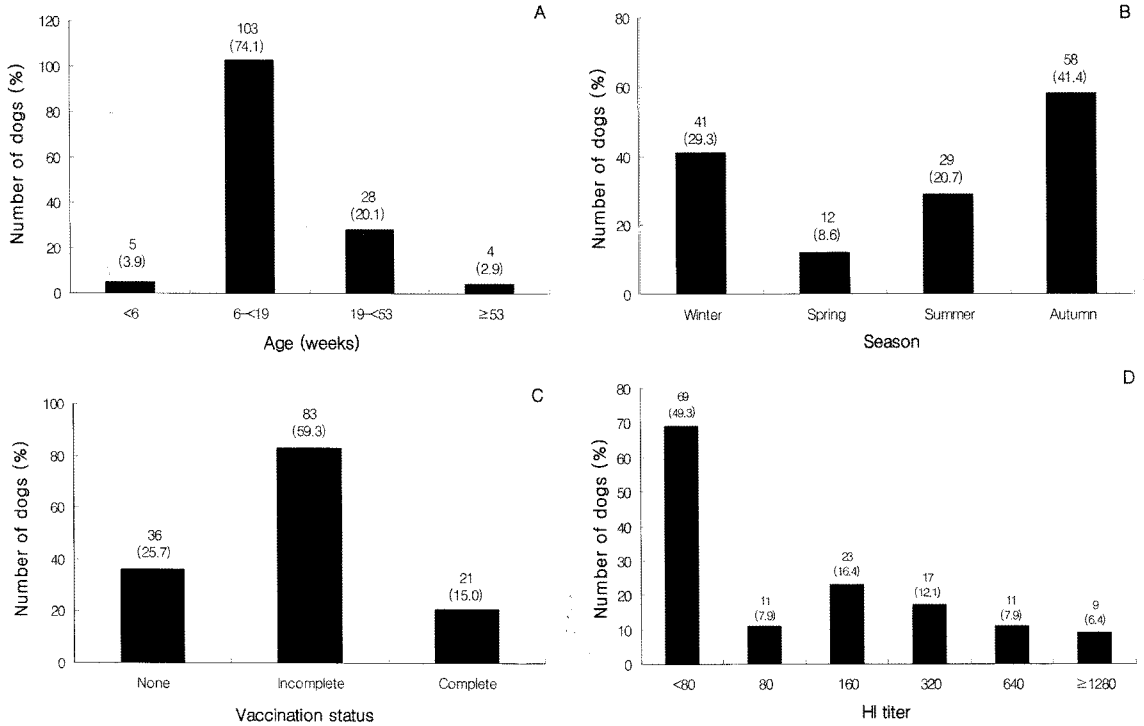

Fig 1. Distribution of the dogs with canine parvoviral enteritis according to study variables (n=140).

(5.0%), and Miniature Schnauzer (5.0%) (Table 1).

The prevalence of clinical CPV infection during autumn (41.4%) and winter (29.3%) was higher than that of summer (20.7%) and spring (8.6%) (Fig 1B).

One hundred and twenty seven (90.7%) dogs of 140 dogs showed diarrhea, and 82 (58.6%) dogs showed vomiting. Seventy six (54.3%) dogs showed lethargy, and 75 (53.6%) dogs showed dehydration. Sixty five (46.4%) dogs showed anorexia, and 17 (12.1%) dogs showed respiratory signs. Eleven (7.9%) dogs showed pyrexia (>39.5) (Table 2).

Vaccination histories were shown in Fig 1C. Thirty six (25.7%) of 140 dogs were not vaccinated, 83 (59.3%) dogs were incompletely vaccinated, and 21 (15.0%) dogs were completely vaccinated.

In distribution of the dogs with CPV enteritis according to HI titer (Fig 1D), 69 (49.3%) of 140 dogs had less than titer 80, 11 (7.9%) dogs had titer 80, 23 (16.4%) dogs had titer 160, 17 (12.1%) dogs had titer 320, 11 (7.9%) dogs had titer 640 and 9 (6.5%) dogs had titer 1,280. Seventy one (50.7%) dogs with CPV enteritis had titer 80 which is above the protective level. There was significant difference in the survival rate of dogs between HI titer <80 group and HI titer 160 group ($P<0.05$).

Logistic regression analysis

Table 1. Distribution of the dogs with canine parvoviral enteritis according to breeds (n=140)

Breed	No. of dogs	%	Breed	No. of dogs	%
Cocker Spaniel	24	17.1	Chow Chow	2	1.4
Shih-tzu	20	14.3	Sapsaree	2	1.4
Alaskan Malamutt	12	8.6	Peruvian hairless Dog	1	0.7
Toy Poodle	11	7.9	Afghan Hound Dog	1	0.7
Jino	10	7.1	Akita	1	0.7
Maltess	7	5.0	Beagle	1	0.7
Miniature Schnauzer	7	5.0	Dachshund	1	0.7
Siberian Husky	5	3.6	German Pointing Dog	1	0.7
Rottweiler	4	2.9	American Pit Bull Terier	1	0.7
Yorkshire Terrier	4	2.9	Pug	1	0.7
Pomeranian	3	2.1	Mixed	14	10.0
Retriever	3	2.1	Total	140	100

Table 2. Clinical signs of 140 dogs with CPV enteritis

Clinical sign	No. of affected dogs(%)
Diarrhea	127 (90.7)
Vomiting	82 (58.6)
Lethargy	76 (54.3)
Dehydration	75 (53.6)
Anoerxia	65 (46.4)
Respiratory sign	17 (12.1)
Pyrexia (< 39.5)	11 (7.9)

Table 3 showed logistic regression analysis of the relationship between study variables and the outcome by CPV enteritis. A percentage of female dogs that survived (70.4%, 38/54) was significantly (P=0.0283) higher than that of male dogs (44.2%, 19/43). Dogs with >18 weeks of age dogs were noted to have a high survival rate (81.0%, 17/21) compare to those of 18 weeks of age (54.9%, 45/82) (P=0.0365). The higher the HI titer, the higher, the survival rate. Other variables were not associated with survival. The final multivariate model included the variables of sex and age group (Table 4). Female (P=0.0323) and >18 weeks of aged were found to be higher survival. Unlikely in the univariate analysis, HI titer was no longer associated with survival.

Discussion

Recently, CPV enteritis had been controlled successfully by the use of low-passage high titer modified live CPV vac-

Table 3. Unconditional logistic regression analysis of the relationship between study variables and the outcome by canine parvoviral enteritis

Variable		No. survived /No. cases	OR* (95% CI)	P
Sex	Male	19/43	1.0	
	Female	38/54	2.47 (1.1-5.6)	0.0283
Age group (weeks)	≤18	45/82	1.0	
	> 18	17/21	3.49 (1.08-11.29)	0.0365
Vaccination status	None	15/25	1.0	
	Incomplete	35/62	0.43 (0.13-1.49)	0.1840
	Complete	15/25	0.05 (0.13-2.0)	0.3270
Season	Spring	4/12	0.31 (0.08-1.24)	0.0971
	Summer	9/15	0.93 (0.27-3.22)	0.9070
	Autumn	28/42	1.24 (0.27-3.22)	0.6573
	Winter	21/32	1.0	
Clinical signs				
Diarrhea	Yes	53/91	0.47 (0.12-1.83)	0.2737
	No	4/ 5	1.0	
Vomiting	Yes	35/58	1.01 (0.46-2.25)	0.9717
	No	15/26	1.0	
Respiratory signs	Yes	58/90	0.34 (0.09-1.23)	0.0990
	No	4/11	1.0	
HI titer	<80	26/54	1.0	
	80 - <160	3/ 8	0.56 (0.12-2.56)	0.4560
	160 - <320	13/16	4.05 (1.05-15.69)	0.0427
	320 - <640	9/11	4.21 (0.84-21.14)	0.0808
	≥640	11/14	2.81 (0.52-15.04)	0.2282

*The 95% confidence interval of the OR was calculated as the antilog (coefficient ± 1.96 x SE of the coefficient).

Table 4. Odd ratios (ORs) and 95% confidence intervals (CIs) of predictor variables associated with the outcome by canine parvoviral enteritis in the final logistic regression model

Variable		No. survived /No. cases	OR (95% CI)	P
Sex	Male	19 / 43	1.0	
	Female	38 / 54	2.47 (1.08-5.66)	0.0323
Age group (weeks)	18	45 / 82	1.0	
	>18	17 / 21	3.49(1.06-11.52)	0.0402

cines (11). However, a number of outbreaks of CPV enteritis were reported throughout the world in spite of intensive vaccination (14,19). Although various commercial vaccines also have been used to prevent CPV in Korea, outbreaks of CPV enteritis continued (27,41). Such problems may arise from the following reasons. One possible explanation for recent outbreaks of CPV enteritis in Korea may be that dogs have low CPV antibody titers from failure of vaccination. Secondly, despite dogs received the vaccines, antibody titers against CPV were not raised. Here may also be problems with improper handling of the vaccine and with the vaccination schedule, for instance, vaccinating puppies still possessing maternal antibodies which may interfere with the generation of immunity. Thirdly, it is occasionally assumed that commercial vaccines in use would not protect against current field virus infections properly even if applied correctly (5,16,26,37).

This study aimed to determine the epidemiological parameters on recent outbreaks and the potential prognostic factors affecting the survival of dogs diagnosed with CPV infection. The overall survival rate of dogs in this study was 44.3% and was lower then 64.0% in Glickman *et al* (14) and 45.7% in Pak *et al* (27) reports. Of the variables studied reported on sex difference in the susceptibility to CPV enteritis and sex was found to be of most prognostic importance (14,24,27). In this study, the prevalence of CPV enteritis between male dogs and female dogs was not different. However, female dogs survived more significantly than male dogs. In the other studies on the risk factors for CPV infection authors reported that there was no association between the risk of CPV enteritis and sex of the affected dogs (19,38).

Most cases of CPV enteritis usually occur under the 6 months of age as puppies have lost their maternal antibody and started to be allowed out and encounter infection (19,24,31). In this study, dogs with CPV enteritis had various age range from 4 weeks to 4 years old, but majority (74.1%) of dogs were from 6 to 18 weeks of age in which was a period for vaccination.

In this study, Cocker Spaniel, Shih-tzu, Alaskan Malamut, Toy Poodle, Jindo, Maltess, and Miniature Schnauzer were shown to be at greater risk for developing CPV enteritis. The finding reported here was different from the concept that CPV enteritis tends to be a disease of certain breeds, specifically Rottweilers and Doberman Pinschers. Houston *et al* (19) propose an Toy Poodles and Cocker Spaniels were at decreased risk for developing CPV enteritis. It is assumed that such difference of our result with the others on breed predisposition to CPV enteritis was observed because breeds at high risk of CPV enteritis such as Rottweilers and Doberman pischers were reared in low number in our area.

Some clinicians suggest that the risk of CPV enteritis for dogs varies with season, but disagree on whether cases are observed mainly in the fall (24,25,40), spring (24), or summer (4). Others suggest seasonal variation dose not exist (38). The inherent stability of CPV and extreme seasonal temperature variations may be contributing factors to the seasonal distribution of CPV enteritis. Dogs in our study were at higher risk for developing CPV enteritis during Autumn (September to November) and at lower risk during the Spring (March to May). Owners should be encouraged to have their dogs vaccinated prior to the high-risk season, particularly if exposure to other dogs is expected.

Clinical signs of dogs with CPV enteritis in this study were multiple. The majority of dogs had a history of diarrhea (90.7%), vomiting (58.6%), lethargy (54.3%), and dehydration (53.6%). Dogs with clinical signs were not significantly associated with survival rate. The initial clinical signs of enteric CPV infection are nonspecific and include anorexia, depression, lethargy, and fever (23). From previous study, lethargy, vomiting, inappetence and diarrhea were the major clinical signs of CPV enteritis (19). With severe dehydration, concomitant infection, and inability to produce a rapid immune response, this syndrome can rapidly progress to systemic shock and death. Death can result secondary to hypovolemic shock, endotoxemia, sepsis or as a consequence of systemic inflammatory response syndrome (23,35).

Of great importance is that dogs received vaccination against CPV with complete protocol had significantly longer survival than unvaccinated dogs (27,33). In this study, 85% of dogs were not vaccinated or incompletely vaccinated and the most of these dogs were under 18 weeks of age. At this age, vaccination of dogs may not be completed. The 49.3% of dogs with CPV enteritis had HI titer against CPV under 80 that is less than protective titer level. Thus, it was considered that recent outbreak of CPV enteritis in Korea might be caused by the failure of vaccination and/or by the inadequate antibody responses to CPV vaccines. However, 50.7% of the dogs with CPV enteritis had titer above 80 that is more than protective titer level. These dogs may have been infected with field CPV strain(s) containing genetic variant responsible for the outbreak (5,16,26,37). Recently, novel CPV variants emerging in cats and dogs have been described and their pathogenicity has been investigated (6,10,12,20).

Importantly, the vaccination programs of pups may need to be revised, considering that dogs with maternally drived antibody titers of 80 or greater (conventionally considered protected) are likely to be susceptible to CPV 2a or 2b infections (12,13). It is impossible to eradicate CPV essentially because of the reservoir in population. Thus, a more extensive use of CPV vaccines should be encouraged in order to reduce the impact of virulent infections in the dog population. Furthermore, as no immunization strategy can eliminate the protective gap between passive maternal immunity and actively acquired immunity, prophylactic measures should include isolation of young dogs from the dog population until the vaccination can be expected to provide protection.

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최근 국내발병 개 파보바이러스성 장염에 대한 역학적 조사

정석영 · 김 두[1] · 안소저 · 박선일

강원대학교 수의학부대학

요 약 : 세계적으로 canine parvovirus (CPV) 고역가 백신이 사용된 후 CPV 감염이 효과적으로 관리되고 있지만 국내에서는 아직도 CPV 장염의 발생이 계속되고 있다. 본 연구에서는 2003년 6월부터 2005년 5월까지 CPV 장염으로 확진된 140두를 대상으로 CPV 장염의 역학적 조사와 CPV 장염에 이환된 환축의 생존에 영향을 미치는 역학적 요인들에 대하여 조사하였다. CPV 장염은 6-18주령의 예방접종을 실시하지 않았거나 불완전하게 실시한 개체에서 주로 발생하였다. CPV 장염에 이환된 개 중 암컷의 생존율이 숫컷보다 높았으며, 나이가 많을수록 생존율이 높았다($P<0.05$). 그리고 HI 항체가가 낮을수록 폐사율이 높게 나타났다 ($P<0.05$). 주요 임상증상으로 설사, 구토, 기면과 탈수증상이 대부분의 환축에서 나타났다. 최근 국내에서 발생하는 CPV 장염은 CPV에 대한 예방접종의 실패와 CPV 백신에 대한 면역반응이 부적당한 것에 기인하는 것으로 생각되므로 면역이 완전히 형성되기 전의 어린 개들은 CPV에 오염된 환경에 노출되지 않도록 예방관리 하는 것이 중요하다.

주요어 : Canine parvovirus, 장염, 역학, 대한민국.