Feline Infectious Peritonitis

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Feline infectious peritonitis (FIP) is a contagious viral disease of domestic and exotic cats. Traditionally FIP has been described as a sporadic disease of low incidence characterized by an insidious onset, persistent nonresponsive fever, and a progressively debilitating course leading to death. Granulomatous inflammatory reactions occur in the abdomen and may occur in the eye and the central nervous system. An accumulation of fluid may be present in the abdomen or thorax or both.

If limited to that description, FIP is far less significant in the cat population than the important viral diseases of cats, such as panleukopenia, respiratory viral diseases, and leukemia. However, recent research findings and clinical reports from veterinarians and cat breeders indicate this view of FIP may be only the tip of the proverbial iceberg. The FIP virus appears to be quite prevalent and may produce far more problems than was originally thought.

History

FIP was first recognized in the 1950s by Dr. Holzworth of Angell Memorial Animal Hospital in Boston. In the mid-1960s the disease was characterized and named infectious peritonitis because of its predilection for producing inflammation of the tissues in the peritoneal (abdominal) cavity and the infectious nature of abdominal ascitic fluids from natural cases. Examination of tissues from infected cats revealed viruslike particles, but extensive attempts to isolate this virus were negative.

The granulomatous, or dry, form of FIP, characterized by lesions in the abdomen, eye, and central nervous system, was recognized subsequently. More detailed studies of FIP became possible when the serological diagnostic test was developed in the mid 1970s by Dr. Niels Pedersen of the University of California, Davis.

The first successful isolation of the FIP virus in cell cultures was accomplished in our laboratory in 1978. Recently, the FIP virus has been propagated in newborn mice by Osterhaus in the Netherlands.

The possible association of the FIP virus with an extensive kitten mortality complex in catteries throughout the United States was first suggested in 1978 by investigators at the Cornell Feline Research Laboratory.

Incidence

The incidence of clinical FIP is relatively low, and cases are usually sporadic, only one or two occurring in a group of cats. However, some multiple-cat households and catteries have experienced several cases over a period of several months. Of the cats necropsied at the University of California, Davis, from 1969 to 1973, the percentage of cases diagnosed as FIP varied from 5 to 13 percent; 1.33 percent of all cats hospitalized were diagnosed as having FIP.

The incidence of infection with FIP virus as indicated by a positive FIP antibody test is far greater than that previously recognized using only clinical symptoms. Subclinical infections (or mild clinical disease not recognized as FIP) are therefore common. The incidence of cats testing positive for FIP antibodies (FIP antibody-positive) varies tremendously among individual subpopulations (households, catteries, colonies). Generally if there is considerable contact between cats within these subpopulations, the positive incidence is either 0 percent or greater than 90 percent.

Etiology

FIP is caused by a virus classified as a coronavirus. Coronaviruses are pleomorphic viruses encapsulated with a lipid-containing protein envelope from which project radiating structures (peplomers) reminiscent of the rays or corona around the sun. Electron photomicrographs of FIP virus particles are shown in the figure.

Coronaviruses of humans and animals generally infect either the respiratory tract (colds or bronchitis) or the intestinal tract (enteritis). Human bronchitis (229E) virus and infectious bronchitis virus of birds are examples of the former while calf coronavirus, canine coronavirus, and transmissible gastroenteritis (TGE) virus of swine produce the latter. Other coronaviruses (such as mouse...
hepatitis virus) produce severe generalized disease. The FIP virus appears to have a predilection during primary infection for the respiratory tract (and possibly for the intestinal tract), but during the secondary disease generalized infection occurs, producing severe effects upon many organs, especially the liver.

FIP virus is relatively unstable and is inactivated by most disinfectants (especially those active against lipids) and by normal environmental conditions. It apparently is inactivated within twenty-four hours at room temperature once it is outside the cat.

Serologic cross-reactivity occurs between FIP virus and TGE virus, 229E virus, and canine coronavirus. Thus while each of these coronaviruses is distinct, they do have one or more common antigens. FIP virus does not cross-react with other known coronaviruses.

Transmission
The exact mechanism of transmission of FIP virus from infected to susceptible cats is not known. Fluid, tissues, and urine of acutely infected cats have been shown to be infectious. Cats that are FIP antibody-positive presumably are chronic carriers and shedders of virus since susceptible (FIP antibody-negative) cats placed in close contact with positive cats will develop positive FIP antibody titers in two to six weeks. It is postulated that the virus is shed from the respiratory system, through the kidney in the urine, and possibly from the intestine in the feces. Direct cat-to-cat contact and contamination of items of common use such as food and water dishes and litter pans would seem to be the most likely methods of transfer of virus. Other possibilities might be transfer by aerosol, transfer on people’s hands, shoes, and clothing, and in utero or neonatal transfer from carrier queens to their kittens.

Infection and Disease
Infection of cats with FIP virus produces a variety of host-parasite interactions that may result in no disease, mild disease, or progressively debilitating, fatal disease. There is much yet to be learned of this host-parasite interaction. Current research in our laboratory is aimed at understanding this interaction and the resulting immune response.

The following is a summary of the various diseases either known or currently postulated to be caused by FIP virus. Further research will undoubtedly add others and delete some from this list.

A. Primary disease
1. Subclinical infection
2. Mild chronic respiratory infection (?)
B. Secondary disease
1. Effusive (wet) FIP
   - Peritonitis
   - Pleuritis
   - Pericarditis
2. Granulomatous (dry) FIP
   - Peritonitis
   - Ophthalmitis
   - Encephalitis
3. Acute hepatitis
C. Kitten mortality complex (?)
1. Repeat breeders
2. Fetal resorption
3. Abortions
4. Stillbirths
5. Fading kittens
6. Acute congestive cardio-myopathy (?)
7. Effusive or granulomatous FIP
8. Endometritis and bloody vaginal discharges of queens
9. Chronic mild respiratory disease of adults and kittens

Primary disease. Initial exposure of a susceptible kitten or cat to an FIP virus-shedding cat results in a primary viral infection within a period of a few days to a few weeks. This infection is believed to occur in the respiratory tract, although the exact mechanism and tissues involved have not been completely ascertained. Most cats show no outward signs of illness during this primary infection. However, some cats may exhibit signs of mild chronic upper respiratory disease, including sneezing and moderate watery ocular and nasal discharges. High fever, loss of appetite, and purulent ocular and nasal discharges have not been associated with primary FIP infection. Cats that exhibit signs of upper respiratory infection may also have low-grade bacterial or mycoplasma infections, the mixed infection accounting for the signs. Although antibiotic treatment will often reduce clinical signs, they may return a week or two after therapy is stopped.

Carrier cats. From epidemiological investigations it appears that most FIP-infected cats remain persistently infected with virus, continue to shed virus, and are a potential source of infection to contact-susceptible cats. The exact mechanism by which the virus is shed, the duration of shed, and the quantity of virus being shed are not known.

Secondary disease. After a period of a few weeks to a few months a small percentage (probably less than 1 percent) of cats infected with FIP virus develop a secondary disease, either the effusive or the granulomatous form of FIP. It is believed that this secondary disease may have an immunopathological component; that is, an adverse immunological reaction occurs that results in damage to tissues, clinical disease, and eventually death rather than recovery and health. This immunopathological component of FIP is under investigation in our laboratory.

Stress may have a role in precipitating this secondary disease. For example, it is known that cats infected with feline leukemia virus and FIP virus have a far greater chance of developing secondary, or typical, FIP. Other forms of stress such as poor nutrition and psychosomatic conditions could also play a part.

Secondary FIP manifests itself initially as an inflammatory response starting around blood vessels (perivasculitis) in the abdominal viscera or omentum, the lung, the pleura and pericardium, the eye, and the central nervous tissue. This inflammatory reaction is a granulomatous response accompanied by a chronic outpouring of inflammatory...
cells and fibrin, resulting in perivasculitis. In some cases there is an active secretion of fluid into the abdominal or thoracic cavity or both, resulting in the effusive (wet) form of FIP. If this process is sufficiently severe, it can produce clinical disease that is usually progressive and eventually fatal after a few days to several weeks.

FIP antibody-positive cats may develop an acute focal viral hepatitis after exposure to large quantities of FIP virus. Death usually occurs within four to seven days of this exposure. Although this form of FIP is seen under laboratory conditions, it is not common under conditions of natural exposure.

Kitten mortality complex (KMC). During 1977 and 1978 it became evident to the authors that a specific disease complex is occurring in breeding catteries throughout the United States. This disease complex results in unusually high levels of reproductive failure and kitten mortality. The exact cause of the complex is not yet known, but there is increasing suspicion that it may be associated with FIP virus infection. This possible relationship is currently under investigation. Clinicians and cat breeders should be aware of the seriousness and extent of the problem and of its possible link with FIP virus.

To date we have investigated over thirty catteries experiencing KMC; some investigations involved extensive laboratory studies, others case histories only. Virological workups have indicated that panleukopenia or the common respiratory viruses are not involved. Very few of these catteries have had a history of feline leukemia virus (FeLV) infection; most have tested negative for FeLV by the immunofluorescent slide test. However, all of the catteries have had a high percentage of breeding queens that show positive antibody titers to FIP virus, and many catteries have a history of one or more clinical cases of

![Electron photomicrographs of individual FIP virus particles. Note the central nucleocapsids, which contain the nucleic acid and the lipoprotein envelope, and the peplomers, or projections, which appear as a corona. The dark bars are 100 nm long (slightly more than one millionth of an inch).](image-url)
effusive or granulomatous FIP. In addition at least three research colonies of cats are FIP antibody-positive and have experienced the same problems with KMC.

Clinical Signs

Primary disease. Most initial infections occurring after natural exposure to virus are subclinical, that is, asymptomatic. Some cats develop a mild chronic upper respiratory infection characterized by sneezing, watery eyes, and watery nasal discharge. These signs may wax and wane for weeks, but the cat does not stop eating and usually does not run a fever. Primary FIP infection is not a life-threatening disease.

Secondary disease. FIP antibody-positive cats that develop secondary disease may show a variety of signs, and the diagnosis is often extremely difficult to make clinically. The onset of illness is frequently insidious; a persistent fever that does not respond to antibiotic therapy is characteristic. A progressive decrease in appetite and body weight occurs, and the cat becomes more and more lethargic. An accumulation of fluid in the abdomen or thorax or both may occur. Cats with lesions involving the liver and kidneys may present with signs of liver or kidney failure. Lesions may be evident in the eye, and occasionally cats show signs of brain and spinal cord involvement.

Although there have been a few apparent recoveries, the mortality of those cats showing definite signs of secondary FIP is in excess of 99 percent.

Diagnosis

The diagnosis of FIP is based on clinical signs, analysis of abdominal or chest fluid, laboratory data, a positive FIP antibody test, and rather characteristic gross and microscopic pathological changes.

Treatment

In most cases treatment does not alter the fatal course of secondary, or typical, FIP. In a few cases temporary remission has occurred after treatment with immunosuppressive drugs. These therapies are not, however, without inherent risks.

Once a definite diagnosis of secondary FIP has been made, it would seem advisable in most cases to recommend euthanasia.

In any case where treatment is tried, extensive supportive therapy and good nursing care are imperative.

Prevention and Control

Vaccination. At present a vaccine is not available to protect cats against FIP infection. Research is under way to characterize the basic responses of cats to FIP virus in order to eventually develop an effective vaccine.

FIP antibody-negative catteries. It is apparent that FIP virus is quite contagious and persistent once it is established within a cattery or multiple-cat household. If a cattery has not yet been infected with FIP virus, it would be prudent to establish a sound management program to prevent introduction.

Each breeding cattery should be screened for FIP virus infection. Since 80 to 100 percent of adult cats in an infected cattery are FIP antibody-positive, testing the serum from 10 to 20 percent of the cats (a minimum of three cats) for FIP antibody should establish the FIP status of that cattery. Cats chosen for testing should be those over one year of age that have had the greatest degree of contact with other cats in the cattery.

Once a cattery is declared FIP-negative, rigid policies and procedures should be established to maintain this negative status. The following should be considered:

1. No cat should enter the cattery unless it comes from an FIP-negative cattery and has tested negative within the past thirty days. Even a cat that has tested negative should be kept in quarantine for two weeks before entering the cattery.

2. Cats from the cattery should not be sent to FIP-positive catteries for breeding and should not contact FIP-positive cats in any other way.

3. Care should be exercised at shows to prevent contact of negative and positive cats. Cats returning from a show should be quarantined for at least two weeks. If any signs of upper respiratory infection occur, the cat should continue to be held in quarantine and should be tested for FIP after three to four weeks.

FIP antibody-positive catteries. Once a cattery is thoroughly infected with FIP virus, it is doubtful that the virus can be eliminated short of depopulation of positive cats and repopulation with negative cats, as has been done for leukemia virus infection. Realizing that the vast majority of FIP-infected cats will live a normal and healthy life (even though they may be shedders of virus), cattery owners may decide to live with the infection. The present limited state of knowledge about FIP makes it difficult to provide specific recommendations for control of FIP infection. However, a few general suggestions might be helpful.

1. Try to maintain the cats within the cattery in as good health as possible. Reduce stress by providing good nutrition and eliminating psychosomatic conditions.

2. Eliminate or isolate FeLV-positive cats.

3. Provide plenty of air circulation, but keep the temperature warm.

4. Use an effective viricidal disinfectant in cleaning. Household Clorox® diluted 1:32 is an effective all-around viricidal disinfectant for feline viruses, including rhinotracheitis, calicivirus, and panleukopenia. It should also be effective against FIP virus. To increase the cleaning properties, Clorox® can be safely combined with the detergent-disinfectant A-33® (Airkem, available from Airwick Industries, Carlstadt, New Jersey 07072) to give a final concentration of 1:32 Clorox® and 1:64 A-33® (4 oz/gal and 2 oz/gal, respectively).
5. Eliminate those breeders that have repeat problems of bloody vaginal discharge, reproductive failure, and loss of young kittens to KMC.
6. Wean kittens as early as possible and hand-rear them away from other cats.

Public Health Aspects
There are no known public health aspects of FIP virus infection of cats. This virus apparently infects only domestic and exotic cats.

Future Research Needs
A number of problems regarding FIP remain for further research. These include (1) understanding the basic immune response to the virus, (2) developing a vaccine, (3) establishing the possible role in KMC, (4) establishing effective control methods, (5) developing an effective treatment, (6) establishing the incidence of FIP-infected catteries, and (7) developing better diagnostic tests.

In order to aid our staff in its study of FIP, we would appreciate having samples to be diagnosed for FIP submitted to the Diagnostic Laboratory, which offers a complete line of feline diagnostic services to veterinarians across the entire country. Such samples provide invaluable data from throughout the United States for the Feline Research Laboratory investigators of feline diseases. Samples submitted for FIP-cattery screening should be labeled FIP cattery survey; those submitted from catteries experiencing reproductive failure or neonatal kitten mortality should be labeled kitten mortality complex. Samples should be submitted by the veterinarian to: Diagnostic Laboratory—Feline Diagnostics, College of Veterinary Medicine, Cornell University, P.O. Box 786, Ithaca, New York 14850.

Summary
FIP virus infection is far more common and of considerably more importance than was previously believed. Initial exposure to the virus usually results in subclinical infection, although mild respiratory disease may occur. This sensitizes the cat so that subsequent exposure to virus or stress may precipitate a secondary disease (effusive or granulomatous FIP) that usually is fatal.

A new disease complex, the kitten mortality complex, which causes unusually high incidences of reproductive failure and death of young kittens, has been seen in many catteries throughout the United States. The cause of this complex has not yet been established, but there is increasing suspicion that it may be associated with FIP infection.

Continued research is urgently needed to provide answers to the many current questions about FIP and to develop effective methods of prevention and treatment.

Further Information
To obtain more information about the work of the Cornell Feline Research Laboratory or to make a donation to support the work of the laboratory, write to:
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