Chlamydophila felis Infection in a Shelter Kitten

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Introduction

This case report describes the management of a six-week-old kitten with a clinical upper respiratory infection caused by *Chlamydophila felis* in an animal shelter. The stray kitten was admitted to the shelter as a singleton with conjunctivitis and nasal congestion. Diagnostic testing revealed co-infection with *Chlamydophila felis*, *Mycoplasma felis*, and feline calicivirus. After four weeks of treatment in foster care, clinical signs resolved fully and subsequent testing revealed clearance of the bacterial infections prior to adoption. This case illustrates the use of foster care to provide effective isolation and biosecurity, prescribed medical treatment, and proper behavioral care for a shelter animal requiring a long course of treatment for an infectious disease.

Chlamydophila felis is an obligate intracellular, rod-shaped, Gram-negative bacterium that is considered to be a primary pathogen in the feline upper respiratory disease complex and a common cause of conjunctivitis in young kittens.[1] Other closely related species include *Chlamydophila psittaci* and *Chlamydophila abortus*, both of which have greater clinical relevance to humans.[2] Unlike *C. psittaci* and *C. abortus*, which are known zoonoses, *C. felis* is highly adapted to the feline species, posing little risk to human health.[2]

Controversy has surrounded the classification of these bacteria throughout the twentieth century.[2] Under current taxonomy, the family *Chlamydiaceae* contains two genera: *Chlamydia* and *Chlamydophila.* With advancements in gene sequencing, six species were differentiated and reclassified from *Chlamydia* to *Chlamydophila* in 1999, including *C. pneumoniae, C. pecorum,*

C. psittaci in birds, *C. abortus* in ruminants, *C. caviae* in guinea pigs, and *C. felis* in cats.[2] The genus *Chlamydia* retains the species *trachomatis,* which is of particular concern as an infectious pathogen in humans, as well as *muridarum* in mice and *suis* in pigs.[2] More recently, additional organisms in the family *Chlamydiaceae* have been identified in cats, including one in older cats and one associated with keratitis, however their clinical significance remains unknown.[3] A recent study conducted in Austria isolated *C. pneumoniae* from the eyes of five cats with conjunctivitis, two privately owned and three from an animal shelter. This species was not previously associated with cats, and more research is needed regarding the clinical significance of these findings. Interestingly, all of these cats were adults over two years of age, which is in contrast to the young age distribution typically seen with *C. felis*.[3]

Infection with a *Chlamydophila* species of bacteria involves infectious elementary bodies attaching to host cells.[2] Phagocytosis introduces the elementary bodies into the cells through phagosomes, where they become reticulate bodies, replicate by binary fission, and release new elementary bodies via exocytosis or cell lysis.[2] During the first two weeks of infection, inclusion bodies are visible in affected cells, characterized by a coccid and basophilic appearance.[4]

C. felis targets and invades conjunctival mucosal tissue. Following a two to five day incubation period, infection typically manifests as unilateral conjunctivitis, usually progressing to bilateral disease within a few days.[1] Transmission of *C. felis* involves close cat-to-cat contact, particularly with ocular secretions, since the organism survives only in live cells.[1] Isolation of the bacteria from vaginal and rectal tissue has been reported, and researchers have attempted to link its presence to abortion and other reproductive abnormalities. However, the organism's potential for venereal transmission and its role in reproductive disturbances have not been well defined.[1] *C. felis* has also been isolated from stomach, liver, lung, kidney, spleen, and lymphatic tissue,[3]

suggesting hematogenous distribution throughout the body.[5] After infection, shedding of bacteria from conjunctival tissue frequently continues for up to 60 days, although it may persist for longer in some cases as evidenced by a reported shedding duration of 215 days in one cat after experimental infection.[1]

Maternally derived antibodies typically provide kittens with passive immune protection for one to two months following birth.[1] Risk factors for acquiring *C. felis* infection include young age, high population density, and stress.[6] The majority of clinical infections occur in kittens between six weeks and nine months of age.[7]

Prevalence data for *C. felis* generally estimates that the pathogen is present in 30% of feline conjunctivitis cases.[8] However, in one small study of 126 client owned cats with conjunctivitis in the United States, only 3.2% were positive for *C. felis*.[9] Worldwide prevalence of *C. felis* in the presence of feline conjunctivitis ranges from 14% in Australia, 18% in Great Britain, 11.5% in Switzerland to 20% in Italy, 27% in Japan, and 45% in Slovenia with various population sampling sizes.[7]

The clinical signs of *C. felis* infection are generally limited to ocular pathology. The hallmark clinical appearance for infection is marked conjunctival chemosis. A common clinical presentation of *C. felis* is a kitten with conjunctival irritation and edema in one or both eyes. Concurrent signs of upper respiratory infection occur in some cases, and mild nasal discharge and sneezing are the most frequent accompanying signs.[5] In some cases, ocular involvement progresses, resulting in severe conjunctivitis with marked hyperemia of the nictitating membranes, serous to mucoid discharge, blepharospasm, and/or conjunctival adhesions.[1] More severe ocular complications such as keratitis and corneal ulcers are rarely seen.[1] Other signs and clinical findings associated with upper respiratory infection, including fever, lameness, oral

ulceration, depression, and inappetence, are unusual manifestations unless co-infection with other pathogens is present. [1,6]

Variations in virulence of *C. felis* have been reported despite the antigenic homogeneity in this species compared to others in its genus and family.[5] Some researchers suggest that the concurrent presence of symbiotic microorganisms (endocytobionts) living inside common amoebae could prolong the survival and increase the pathogenicity of *Chlamydophila* species including *C. felis.*[5] The potentially synergistic role of these organisms and the significance for control and prevention has not been elucidated.[5] Coinfection with respiratory viral pathogens, other bacterial respiratory pathogens, *Streptococcal* species, or immunosuppressive viruses such as feline immunodeficiency virus (FIV) can also increase duration and severity of clinical presentation.[5]

The most common differential diagnoses for *C. felis* include other pathogens commonly implicated in feline upper respiratory disease including the viral agents feline herpesvirus-1 (FHV-1) and feline calicivirus (FCV).[6] Common bacterial pathogens include *Mycoplasma, Bordetella bronchiseptica,* and *C. felis.*[6] In particular, FHV-1 is commonly associated with conjunctivitis and therefore represents a leading differential for *C. felis.* Coinfection with one or more of these agents is common. In addition, both *Streptococcus equi* subspecies *zooepidemicus* and H1N1 influenza virus have been implicated as causes of respiratory disease in cats on rare occasions.[10] Other differential diagnoses for conjunctivitis in cats include alternative causes of conjunctival hyperemia including blepharitis, uveitis, glaucoma, scleritis, dystichia, entropion, and conjunctival foreign body.[11]

As previously stated, the high frequency of coinfection that occurs in feline patients with upper respiratory disease warrants a closer review of the common contributing agents. In

particular, FHV-1 is a feline-specific DNA alpha herpesvirus and represents the leading cause of surface ocular lesions in cats. The virus possesses a high degree of antigenic homogeneity resulting in little variation among strains.[6] Upon initial infection of a naïve cat, viral shedding in ocular, nasal, and oropharyngeal secretions usually begins within days of infection.[12] Transmission occurs via direct contact and droplets.[12] Clinical signs of FHV-1 infection are most severe when young kittens are initially infected[13] and include upper respiratory signs with frequent ocular manifestations such as conjunctivitis, conjunctival hyperemia, and serous epiphora.[14] Respiratory signs can range from mild to severe, and may occasionally progress to pneumonia.[15] In addition to being a conjunctival pathogen, FHV-1 is also a corneal pathogen, and viral replication in the corneal epithelium can cause epithelial cell erosion.[14] In fact, FHV-1 is the primary causative agent responsible for corneal ulceration in cats, which is also a common clinical finding in many cases.[15] Furthermore, the presence of dendritic ulcers (e.g., linear, branching ulcers) is considered pathognomonic for FVH-1 infection. Chronic ocular sequelae also occur in some cats, including uveitis, corneal sequestration, and keratitis.[14,15]

Following primary infection, the FHV-1 virus enters a state of latent infection in the trigeminal nerve ganglion of almost all recovered cats.[12] Approximately 45% of latently infected cats periodically shed the virus either spontaneously or induced by stress.[12,13] In a study correlating the results of PCR testing, cell culture, clinical signs, and necropsy findings in 22 shelter cats with upper respiratory disease, quantitative PCR was accurate in differentiating between active and latent infections and demonstrated significantly greater clinical relevance with the former.[16] PCR is the most sensitive method of detecting FHV-1.[14] Vaccination against FHV-1 provides partial immunity and is considered a core requirement for all cats.[17]

Feline calicivirus is an unenveloped, single stranded RNA virus that is reportedly seen in 20-50% of feline upper respiratory disease cases.[6,12] This virus persists in the environment and requires the use of disinfectants with proven efficacy against unenveloped viruses under clinic and field conditions.[12] As with other RNA viruses, frequent mutation is common, resulting in great diversity among FCV strains which can significantly alter the pathogenicity among them.[6] As such, FCV infection can cause a wide variety of clinical signs ranging from fever and oral ulceration to stomatitis, skin ulceration, and pneumonia.[15] Although not historically considered a primary pathogen associated with ocular pathology, a study of 99 cats with ocular surface lesions demonstrated that 30 of the cats tested were PCR positive for FCV.[15] In eleven of those cats, FCV was the only infectious agent identified.[15] The authors concluded that some FCV strains may have a propensity to cause ocular disease, and furthermore that FCV should be considered as a differential diagnosis in cats with acute inflammatory ocular disease, particularly when accompanied by oral lesions such as ulceration or gingivitis.[15]

A carrier state with continued shedding of FCV is recognized in up of 25% of healthy cats and can persist for months or longer after initial infection.[15] Virulent systemic calicivirus is a rare but extreme manifestation resulting from distinct mutations, which typically arise under the pressure of high density housing.[6] Affected cats develop severe polysystemic signs that can rapidly progress to death.[6] Vaccination against FCV provides partial immunity against some strains of the virus and is considered a core requirement for all cats.[17]

Secondary bacterial invasion is common with viral respiratory infections, but in some instances a bacterial agent may be the primary pathogen. In addition to *C. felis, Mycoplasma felis* and *Bordetella bronchiseptica* have been implicated as potential primary pathogens and are frequently reported as coinfections in cats with upper respiratory disease. *Mycoplasma* spp.

bacteria lack a cell wall and preferentially associate with mucosal surfaces such as the feline respiratory tract, conjunctiva, and genital tract.[18] Determining the clinical significance of this genus of organisms, including *M. felis*, has been difficult since it is found in the respiratory tract and conjunctival tissue of healthy cats suggesting it may be component of normal flora.[19] Great interest remains in its role as a co-pathogen since it is associated with cases of polyarthritis, lower respiratory tract disease, and conjunctivitis with greater prevalence than in healthy animals although still typically accompanied by another pathogen and in animals less than six months of age.[18,19]

Bordetella bronchiseptica is an aerobic, gram-negative coccobacillus which colonizes the mucosal surfaces of the oronasal cavity and destroys the cilia of the respiratory epithelium through release of inflammatory toxins.[12] While typically considered a primary culprit in infectious respiratory disease in dogs, swine, and rodents, the agent can cause disease in cats similar in clinical appearance to FHV-1 and FCV.[8] Coughing may be seen in feline cases but is often absent, and cats may continue to shed the pathogen after resolution of clinical signs.[8] Vaccination is not considered to be a core requirement for cats, and current professional recommendations limit use to situations where diagnostics have linked the pathogen to clinical disease in a feline population or where cats reside in close contact to infected dogs.[17]

Differentiating *C. felis* from other respiratory pathogens involves a diagnosis often based on the presence of typical signs, although laboratory testing is necessary for a definitive diagnosis. Polymerase chain reaction diagnostic testing from conjunctival swabs is the preferred method for diagnosis of *C. felis* in cats with consistent clinical signs of disease.[1] Sampling technique is critical and must ensure adequate harvesting of cells from tissue to detect the intracellular bacteria.[1] Both false negatives from inadequate sampling and false positives from

sample contamination either at collection or at the laboratory can threaten the accuracy of PCR testing making rigorous quality control in the field and in the laboratory essential.[5] A Canadian study found significant variability between laboratories in PCR detection of *C. felis* from the same samples. This illustrates the importance of interpreting diagnostic test results with caution, and further underscores the importance of interpretation in conjunction with clinical signs.[13] Recently, real-time PCR became available for the diagnosis of *C. felis*. This technique represents a diagnostic advancement over conventional PCR in that it quantitates the amount of pathogen in the sample.[20] Real-time PCR also reduces the risk of sample contamination due to reduced requirement for sample handling.[20] This technology was developed primarily for chlamydial infections of human and livestock significance, but is now commercially utilized in the diagnosis *C. felis*.[20]

Although considered the gold standard for evaluating diagnostic test performance, culturing this organism is not recommended for clinical diagnosis.[1] The bacterium's delicate nature makes generating reliable growth difficult[1] and the two week time course often necessary for obtaining results is impractical.[21] Likewise, immunofluorescence assay (IFA) requires cell culture to detect antigen, thus this technique poses the same challenges.[21] A highly specific ELISA assay is also available for detection of *C. felis* antigen, but unfortunately the sensitivity of this test is highly variable, making it an unreliable screening tool due to the frequent occurrence of false negative results.[5] In addition, neither ELISA, nor IFA tests for bacterial antigen are capable of distinguishing between previous vaccination and natural infection with a field strain.[21]

In some instances, antibody titer testing may be used to support the diagnosis of *C. felis*. Because clinical signs often precede a rise in antibody titers, false negative results (e.g. the absence of titers) may be seen in acute cases, thus reliance on antibody testing alone for the

diagnosis of acute infections is not typically recommended.[5] However, the presence of positive titers can lend credence to diagnosis especially in the absence of vaccination and particularly when high titers are found in populations of cats or in chronic cases.[1] Researchers have also described an antibody ELISA test that satisfactorily differentiated between 44 cats that had been previously vaccinated against *C. felis* using an inactivated product and 670 non-vaccinated cats. The sensitivity of this ELISA antibody test for screening these cats was similar compared with antigen IFA.[21] In the future, commercial applications of this technology may provide an in-clinic antibody screening test as a convenient diagnostic option.

Cytologic examination of conjunctival smears with Giemsa stain offers the potential for faster diagnosis without the turnaround time required for antigen and antibody testing and deserves note.[1,4] In a study comparing cytologic diagnosis with PCR analysis, visual detection of characteristic inclusion bodies was highly sensitive; however, suspicious inclusion bodies were also identified in negative cases, resulting in low specificity even with experienced clinical pathologists evaluating the samples.[4] Structures with a similar appearance include *Mycoplasma* inclusion bodies and mucin or melanin granules.[4] The necessity for high quality slide preparation and expertise in cytopathology, combined with the waning presence of inclusion bodies after the initial two weeks of infection, significantly limit the usefulness and reliability of this tool for diagnosing *C. felis* in most clinical settings.[4]

The treatment of choice for confirmed *C. felis* infections is a minimum of four weeks of doxycycline dosed at 10 mg/kg PO q24 hours.[1] Because recrudescence is common with shorter treatment times, the minimum recommended treatment duration is 4 weeks. However, in cases with persistent clinical signs, the duration of treatment should always be extended at least two weeks beyond the presence of clinical signs.[1] Like other tetracyclines, doxycycline is a

bacteriostatic antibiotic that inhibits protein synthesis by binding to 30S ribosomal subunits.[22] Elimination from the body is primarily through feces with only a small amount of renal and biliary excretion making it a safe choice even in patients with renal dysfunction.[23] In contrast to other tetracyclines, it is associated with a lower incidence of side effects such as discoloration of enamel in young animals due to decreased calcium-binding action, is well absorbed orally, and has a longer half-life which permits once daily dosing.[5] Its spectrum of activity also includes most *Mycoplasma* spp., spirochetes, and many gram-positive bacteria including *Bordetella bronchiseptica.*[22] Notably, in addition to the more common gastrointestinal signs (i.e. nausea, diarrhea), doxycycline-induced esophagitis represents a serious potential adverse effect necessitating use of either a suspension formulation or water bolus following administration of a tablet.[24] If passage through the esophagus is delayed, doxycycline can cause severe esophagitis, ulceration, stricture, and rupture of the esophagus.[24] A bolus of several milliliters of water should always follow administration of tablets or capsules.[24] Compounded suspensions may be used to reduce this risk, but a water bolus is still recommended.[5] A recent study demonstrated that liquid preparations are only stable for seven days.[24]

Other antibiotic treatment options may be considered including clavulanic acid-potentiated amoxicillin and fluoroquinolones. Experimentally infected cats in a laboratory setting remained free of infection with *C. psittaci* for six months following a four week course of treatment with clavulanic acid-potentiated amoxicillin,[25] and these results have been extrapolated to also hold true for *C. felis.*[5] Clavulanic acid-potentiated amoxicillin is a bactericidal penicillin that inhibits beta-lactamase through competitive binding; the most common adverse effects are gastrointestinal signs including anorexia, vomiting, and diarrhea.[23] Enrofloxacin is a bacteriocidal fluoroquinolone with broad spectrum efficacy against both gram-negative and

gram-positive bacteria.[26] It is stable after oral administration and prevents DNA synthesis by inhibiting the DNA-gyrase topoisomerase responsible for DNA supercoiling.[23] A small study involving the administration of enrofloxacin demonstrated that minimum inhibitory concentrations were achieved in serum, saliva, and tears of both healthy cats and those with respiratory signs.[26] In that study, fifteen cats with confirmed *C. felis* infections were treated with either doxycycline or enrofloxacin for two weeks. There was no statistical difference in outcome between the two groups, but three cats in each group remained positive for *C. felis* after two weeks of treatment. The investigators concluded that a longer course of treatment is needed, and that the lower occurrence of side effects and equivalent performance of enrofloxacin in this study suggest that it should be considered in the treatment of *C. felis* cases.[26] Cartilage abnormalities in growing animals, gastrointestinal effects, and dose-dependent retinal degeneration remain concerns in cats treated with enrofloxacin and warrant caution in the use this medication.[18]

Pradofloxacin has been suggested as an alternative fluoroquinolone that retains broad spectrum bactericidal activity without retinal effects in toxicity studies.[18] In a double-blind study of 23 cats with *C. felis* infection, treatment with pradofloxacin dosed at 5 mg/kg PO q24 hours was compared with doxycycline dosed at 10 mg/kg PO q24 hours over the course of 42 days.[18] All cats treated with doxycycline completely cleared the *C. felis* infection. Two cats treated with pradofloxacin failed to clear *C. felis* infection at the conclusion of the study, and two others tested negative at day 28, but positive with a relapse of clinical signs occurring in one of these cats on day 42. The authors concluded that doxycycline remains the treatment of choice, but that pradofloxacin may be considered as an alternative when side effects of doxycycline are of concern.[18] Both doxycycline and pradofloxacin were effective at eliminating *Mycloplasma* spp. in this study.[18]

Topical treatment with ophthalmic tetracycline ointment three to four times daily may be considered as an adjunctive treatment. However, topical treatment alone is inadequate for clearance of infection unless accompanied by systemic therapy. Adjunctive topical therapy may enhance drug concentrations on the ocular surface, and concurrent use of artificial tears may also provide lubrication to enhance patient comfort.[5]

The amino acid lysine has also received attention as an adjunctive therapy for feline respiratory disease and conjunctivitis. In vitro studies that demonstrated antiviral activity prompted clinical use and investigation of lysine as an adjunctive treatment in cases of respiratory disease, particularly those involving infection with FHV-1.[27] Unfortunately, field studies have not substantiated its usefulness. In one study of lysine efficacy conducted under field conditions at an animal shelter, the impact of lysine supplementation on clinical signs as well as conjunctival and oropharyngeal shedding of FCV, FHV-1, and *C. felis* was evaluated. The researchers failed to demonstrate any benefit, and furthermore demonstrated that lysine administration was associated with enhanced clinical signs and shedding in this setting.[27]

All of the species in the genus *Chlamydophila* have zoonotic potential. Fortunately, the current scientific consensus strongly suggests that the zoonotic risk of *C. felis* is low.[1,2,7] Case reports of disease in humans attributed to *C. felis* diagnosed with follicular conjunctivitis, atypical pneumonitis, endocarditis, and glomerulonephritis have largely been presumptive due to close contact between an immunocompromised patient and a cat.[2] In one case, researchers demonstrated that *C. felis* isolated from the eye of an immunosuppressed human patient with conjunctivitis matched the isolate from the patient's cat.[2] The risk can be summarized by stating that *C. felis* has the rare potential to cause conjunctivitis in humans, particularly those who are

immunocompromised. Basic biosecurity precautions including gloves and hand-washing are warranted when handling infected cats.[2]

Commercially available vaccines against *C. felis* include both inactivated and modified live products, and are frequently included as a component of multivalent formulations (i.e., combination products that also afford protection against FCV, FVH-1, and feline panleukopenia virus).[1] Challenge studies have demonstrated no impaired performance among any of the components as a result of combination in the multivalent products.[17] Vaccination against *C. felis* is not routinely recommended for all cats; current recommendations reserve its use for multi-cat environments where *C. felis* has been diagnostically demonstrated in conjunction with compatible clinical disease.[17] Although it does not prevent infection, it may be useful in the control of clinical disease by reducing the severity of signs associated with infection.[2,17] Although data that demonstrate the approximate onset of immunity following vaccination is lacking, challenge studies conducted one year following vaccination demonstrate persistent reductions in clinical signs.[17] Some reports indicate a higher incidence of vaccine reactions, including lethargy, pyrexia, anorexia, and lameness, within three weeks after administration of products containing *C. felis* than those without it.[17]

There has been interest in exploring whether other vaccine formulations could provide enhanced protection against *C. felis*. Researchers in Japan demonstrated in a challenge study that an experimental inactivated vaccine induced higher antibody titers against *C. felis* with milder clinical signs, no pathogen found in other organs, and fewer side effects than commercially available vaccines.[28] This vaccine did not prevent conjunctival or nasal shedding, demonstrating the difficulty in establishing local immunity against *C. felis* in ocular and nasal tissues.[28] Future research has the potential to improve preventive options for this infection.[28]

Given the risk factors for *C. felis* infection (e.g. young age, high population density, and stress), most shelter environments pose a relatively high risk for disease transmission if infected cats are introduced to the population. The risk of transmission of *C. felis* may be mitigated when cats are housed singly or only in familiar groups because transmission requires close cat-to-cat contact. Fortunately, the bacterium is extremely fragile and its absence of environmental durability makes fomite transmission highly unlikely.[1] In contrast, colony housing, particularly of unfamiliar young cats, may facilitate transmission. The risk of *C. felis* infection is likely greater in animal shelters housing young cats for long periods of time, especially in groups with high turnover and/or population density.[6] Furthermore, one can expect the risk to increase during kitten season in the months around May due to the increased population density of at-risk kittens that most shelters experience during this time.[29]

Overall, the prevalence of *C. felis* in animal shelters has been low in epidemiological surveys. In one survey of 250 cats at an open-admission animal shelter in Western Canada, 28% of cats tested PCR positive for at least one pathogen associated with upper respiratory disease, but none tested positive for *C. felis.*[10] Another epidemiological survey tested cats via PCR for respiratory pathogens in four types of shelter settings in Florida and Georgia. Out of 140 cats housed in animal shelters for less than a month, 3% of healthy cats tested positive for *C. felis,* while 8% of cats with clinical respiratory disease tested positive. In comparison to cats housed in long term sheltering facilities, the prevalence was strikingly similar. The study also evaluated cats in foster-based programs. This population consisted mostly of kittens less than six months of age. Not surprisingly, a relatively higher prevalence of *C. felis* was demonstrated: 10% among healthy kittens and 24% among kittens with clinical respiratory disease.[30]

In a study investigating the pathogens present in 22 cases of severe feline upper respiratory disease that resulted in euthanasia in an animal shelter, *C. felis* was detected in only one cat with conjunctivitis. Diagnostics utilized included PCR testing, cell culture, clinical signs, and necropsy, but many of the cats had been treated with antibiotics prior to testing.[16] In comparison, diagnostic surveys of 81 cats from four cases of animal hoarding found an overall *C. felis* prevalence of 26%, with a range of zero to 60%. These findings highlight the elevated risk and need for clinical suspicion in cats housed in conditions of high density with poor husbandry.[31]

Treating a population of *C. felis* infected cats requires thorough compliance to ensure that every animal receives the recommended full course of treatment.[5] As previously discussed, viral co-infections including FCV and FHV-1 are frequently present in animal shelter populations and may increase the severity of clinical disease and complicate assessment of treatment efficacy.[5] Preventing exposure of new cats is crucial and is most reliably achieved by temporarily suspending admission of new cats until treatment of resident cats is completed; at a minimum, isolation of infected cats with strict biosecurity and hygiene is essential to halt the cycle of exposure.[5] Due to compliance and re-infection concerns, a longer course of treatment lasting six to eight weeks might be necessary for population level infection resolution.[5]

When *C. felis* has been diagnostically confirmed in a shelter population with significant clinical disease, vaccination of the population may be warranted.[17] However, routine vaccination of shelter cats, including those in long-term group housing or with young cats and high population turnover, is controversial. Although these cats are at increased risk,[1] resource expenditure is seldom justified given the generally low prevalence of disease, the lack of

sterilizing immunity conferred by the vaccine, the complication of co-infections, and potentially elevated risk of adverse reactions.[17]

Professional guidelines dictate that the retroviral infection status of cats entering a new home should be determined, testing should be repeated 30-60 days after a negative test result, and positive test results should be confirmed through appropriate diagnostic retesting.[32] Since coinfection with a retrovirus, either feline leukemia virus (FeLV) or feline immunodeficiency virus (FIV), can exacerbate the severity and duration of clinical disease caused by respiratory pathogens including *C. felis,* establishing the retroviral infection status of any clinically ill cat provides important prognostic information.[32] Diagnosing retroviral infections presents unique challenges in the context of the animal shelter due to the implications for biosecurity within the shelter, expectations of future adopters, and decisions about how to allocate limited treatment resources.[29] Confirmatory and repeat testing, as well as testing all cats, are often not feasible for many animal shelters.[29] Shelters may opt to test only cats at highest risk of carrying a retroviral infection, including those with clinical respiratory signs, and those with the greatest risk of transmitting an infection, such as cats entering group housing.[29] In some instances, shelters may elect to test kittens for FeLV but not FIV. This is because the presence of maternal FIV antibodies may produce false positive test results, confounding the diagnosis of FIV in kittens younger than six months of age.[32] It is particularly crucial for shelters to disclose to adopters whether cats have been tested and to clearly issue recommendations for follow-up testing after adoption.[29,33] New adopters must be educated about the risk posed by un-tested cats to other cats in the home and the importance of keeping the new cat separate until the retroviral infection status is determined.[29,33]

Weight monitoring is of particular importance in the context of managing upper respiratory disease in shelter cats and kittens. Immunity may be compromised when animals experience inadequate nutritional planes or dehydration, both of which may contribute to the development of and complicate recovery from respiratory disease.[29,34] One study demonstrated a positive correlation between weight loss and stress among adult cats housed in an animal shelter with cats displaying greater behavioral signs of stress being more likely to develop upper respiratory infection.[35] In kittens, weight loss or inadequate weight gain are particularly sensitive indicators of nutritional compromise and dehydration, thus regular monitoring is especially crucial in small kittens.[36] Normal weight gain in healthy kittens should range from 10 to 15 grams per day with a daily weight gain of less than seven grams often representing one of the first signs of illness and dehydration.[29, 36]

Behavioral welfare constitutes a crucial additional consideration in treatment of upper respiratory disease in the animal shelter setting. In particular, a cat undergoing a course of treatment for *C. felis* necessitates long-term care in the shelter, which is defined by professional animal shelter management guidelines as a length of shelter stay exceeding two weeks.[37] Animals residing long-term require spacious enriched housing with the opportunity for exercise and exploration.[37] Although isolation housing may impede provision of enrichment due to restricted access and biosecurity concerns, the behavioral needs of animals undergoing long-term medical treatment must be given equal priority as husbandry and physical health.[37]

Human contact constitutes one form of enrichment that can promote both behavioral and physical health. In a study of 250 shelter cats, daily sessions of positive physical contact with people led to improved mood assessment ratings (which included anxious, frustrated, or content), increased immunoglobulin S-IgA as a measurement of mucosal immunity, and decreased

development of clinical upper respiratory signs.[34] Cats in the control group displayed higher rates of shedding respiratory pathogens including *M. felis* and *Bordetella bronchiseptica* measured by PCR than the cats receiving daily human contact sessions.[34]

Young cats under the age of four months also have unique behavioral needs in the animal shelter setting. Felines have a narrow phase of development from approximately three until eight weeks of age during which they are most amenable to exposure to humans and other novel stimuli.[38] Experiences during this sensitive period of socialization impact how the cat will interact with people, other species, and new situations encountered throughout adolescence and adulthood, and therefore contribute to determining the cat's adaptability and suitability as a socialized house pet.[39] Increased duration, frequency, and variability of handling during the sensitive period has been shown to improve the frequency of affiliative behaviors towards humans[40] and the inclination to approach novel objects when the cat is four to seven months of age.[39] Five to ten week old kittens handled by five people were more likely to interact, play with, and show affection toward humans than those handled by only one person.[41] The positive results of socialization during the sensitive period are more apparent in kittens raised in a home setting than in an institutional setting due to more frequent opportunities for handling and greater variation in routine and stimuli.[39]

Although weaning may be accomplished by six to eight weeks of age, it can be beneficial for kittens to remain with their mothers for a longer period of time when feasible. The mother-kitten relationship is crucial for normal social and emotional development. Furthermore, interaction with littermates is also important for proper development. In particular, early maternal separation as well as singleton status have been associated with the development of problem behaviors including fear, play aggression, and wool sucking, among others. Studies that

clarify the relationship of these behaviors to age of weaning and singleton status are lacking. Stressors on the queen before and after the birth of kittens can affect subsequent behavior making kittens more susceptible to stress themselves. Stressful events, including human handling during treatment, can result in the display of fear to humans that persists to adulthood.[39]

Because of the crucial significance of the sensitive period for future socialization, professional guidelines for shelter management emphasize that care for young kittens is often best accomplished outside of the shelter environment through foster care, transfer to an outside rescue group, or adoption.[37] Provision of husbandry for these juveniles within the shelter facility must prioritize both behavioral welfare and biosecurity since this age group is also immunologically immature and at greatest risk from infectious disease.[37]

Although the prognosis for *C. felis* is good for individual animals, the combination of the infectious potential, length of treatment required, and propensity to affect young kittens makes *C. felis* a particularly challenging disease to manage in a shelter setting. Early recognition, isolation, and appropriate treatment are required for successful management of individual animals as well as to mitigate the risk of transmission in a population. Management practices will vary among shelters depending on the organization's mission, capacity for care, and resources. The use of Asilomar Accord intake classification categories of healthy, treatable-rehabilitatable, treatable-manageable, and unhealthy-untreatable can assist shelters in determining allocation of scarce resources based on expectations for provision of care to young kittens considered reasonable in their community.[42]

Clinical Report

A six-week-old intact male domestic shorthair kitten was admitted to an animal shelter overnight through a night drop kennel in September 2014. The animal shelter was a well-resourced, privately operated, open admission facility located in a cool, dry mountainous climate. The organization held municipal contracts to provide sheltering services for two counties situated in affluent suburban areas. Approximately 2,000 dogs and 1,500 cats were admitted to the shelter annually with puppies accounting for 20% of dog intake and kittens accounting for 50% of cat intake. Kitten intake historically peaked in April through June. Stray cats accounted for 47% of the feline intake, while the vast majority of the remaining cats were surrendered by their owners. Feline live release rate was 87% largely due to the shelter's robust adoption program, including a return to owner rate of 8.2% for cats. Onsite animal census at the time that the kitten described in the case was admitted was 120 dogs and 230 cats. Average length of stay to adoption for cats was 40 days. Very few kittens were housed in the shelter or in foster care at this time, and medically skilled foster homes were available.

The shelter's facility consisted of a large, recently renovated structure with two levels. Feline housing options on the main floor included a room for holding stray cats in double-compartment stainless steel cages and a separate room for housing cats awaiting adoption in double-compartment cages with plexi-glass doors. The upstairs level consisted of smaller rooms containing single compartment stainless steel cages. Each of these rooms was designated for a specific purpose: one was used for isolation and treatment of sick cats, one was designated for healthy cats awaiting foster placement, and one was used for temporary housing of cats returning from foster care for sterilization surgery. In addition, a separate room contained six night drop kennels, which were accessible to the public, to allow animals to be left safely at the shelter after

hours. Signage was present requesting completion of admission forms for these animals in order to obtain basic information about their ownership, medical, and behavioral history. However, animals admitted through the night drop kennels were subject to a five-day stray hold unless the shelter could contact the surrendering party to confirm proof of ownership.

Shelter staff included a full-time veterinarian and four veterinary technicians who were exclusively dedicated to providing medical oversight of the shelter's animals, including those housed on site and in foster care. Other key management positions included the operations director, animal care and client care supervisors, director of training and behavior, foster care coordinator, and rescue coordinator. In addition, the animal care team consisted of 30 staff members who were responsible for daily animal husbandry including cleaning and feeding. The shelter's foster program included approximately 100 approved foster homes, which were housing 80 animals at the time of this case. The shelter's behavior department provided training and behavior modification interventions for the shelter's dogs, while feline behavior was overseen by the animal care supervisors and the operations manager. An active volunteer program provided a variety of daily enrichment activities for cats on the adoption floor, and the program was being expanded to include the cats in stray holding at the time of this case.

Defined policies and protocols aided the shelter in allocating resources efficiently beginning with intake assessment. The shelter used Asilomar classifications for intake status, and shelter policy called for placement of all healthy and treatable-rehabilitatable cats through adoption or rescue. Many treatable-manageable cats were also placed; the availability of existing skilled, medically trained foster homes was crucial for the shelter to achieve these outcomes. To improve the outcome of many animals classified as treatable-rehabilitatable, stray puppies and kittens under eight weeks of age were authorized to enter foster care immediately upon

admission for the duration of their stray hold. Consistent use of the Asilomar intake classifications allowed the shelter to ensure that it targeted resources appropriately.

Protocols for animal intake emphasized reduction of disease transmission risk. Intake processing for all kittens was performed in a biosecure room designated for incoming cats. In this room, staff routinely cleaned and disinfected surfaces and equipment between patients using accelerated hydrogen peroxide[a] at the viricidal concentration of 1:16 with a contact time of five minutes; they also changed gloves and washed their hands. A veterinary staff member performed a physical examination, administered preventive medical treatment, conducted retroviral testing, and identified animals in need of further veterinary examination and treatment. For kittens under 20 weeks of age, routine intake treatments included the administration of a parenteral multivalent modified live vaccine against feline panleukopenia virus, FHV-1, and FCV, and oral broad spectrum anthelmintics including pyrantel pamoate[b] at a dosage of 20 mg/kg PO once and ponazuril[c] at a dosage of 50 mg/kg PO q24 hours for three days. Topical parasiticides were not routinely applied due to the rarity of fleas in the shelter's geographic region but could be administered if indicated by the physical examination findings.

Medical protocols dictated management of infectious diseases based on the practicality of resource investment. Clinically healthy cats were tested for FeLV but not FIV based on the cost of testing and the low prevalence of FIV in the shelter's geographic area. Cats testing positive for FeLV were not made available for adoption at this shelter; euthanasia was considered the only outcome option for these cats if they could not be returned to their original owner. The shelter policy reflected a historical difficulty finding homes for FeLV positive cats. Clinically ill adult cats were tested for both FIV and FeLV. All cat adopters were advised to follow up with their

primary care veterinarian to discuss FIV testing and FeLV re-testing prior to co-mingling a newly adopted cat with felines already present in the home.

Historical patterns of disease in the shelter's feline population primarily demonstrated endemic upper respiratory disease complex affecting 10-15% of cats on site at any given time. While the specific pathogens responsible had not been documented previously, clinical signs followed a distinct pattern of sneezing with clear ocular and nasal discharge two to four weeks after intake. Affected cats were moved to isolation, and clinical signs typically resolved within ten days with routine supportive care and monitoring. Complications of fever, inappetence, oral ulceration, marked conjunctivitis, blepharospasm, and ocular surface lesions were rare. In contrast, dermatophytosis was rarely seen in this shelter, and intake protocols prioritized thorough screening to minimize the risk of its introduction to the on-site population.

The author was a visiting staff veterinarian for several months at this shelter. The author's role in management of this case began at intake and included oversight of initial diagnostics and treatment in compliance with shelter policy and in consideration of the shelter's resources. The author served as the primary veterinarian in this case with responsibility for ongoing medical decisions and case management, including diagnosis, treatment, and monitoring of the patient, through its resolution as well as through the patient's adoption process.

Immediately upon finding the kitten in the night drop kennel in the morning, the surrender report was reviewed and the kitten was examined. The individual surrendering the kitten had completed an after-hours surrender report, which was found with the kitten. The report stated that the animal was found wandering outdoors alone and included its location of origin, but neither contact information, nor any additional information were provided. Medical, behavioral, and vaccination history were all unknown. No feces, urine, or vomitus was present in

the kitten's kennel. In addition, no other kittens of similar age or size were present in any of the night drop kennels.

In accordance with shelter protocol and the unknown history of the patient, physical examination was conducted in a biosecure room designated for incoming cats. On initial physical examination, the kitten was quiet, alert, and responsive. Rectal temperature was normal at 38.7 degrees Celsius (normal range 37-39.5 degrees Celsius), pulse was normal at 160 beats per minute, and respiratory rate was normal at 36 breaths per minute. Thoracic auscultation revealed referred upper airway sounds audible in all lung quadrants on inspiration. Expiratory lung sounds and cardiac sounds were normal. Femoral pulses were strong and synchronous.

Mucous membranes were pale pink and semi-dry with a capillary refill time of less than two seconds. Skin turgor was subjectively slightly reduced; these findings were consistent with mild clinical dehydration estimated at 5-6%. The kitten weighed 0.55 kg and appeared unthrifty and thin. A body condition score of 3.5/9 was assigned based on palpable and visible ribs with minimal overlying fat.

Ocular examination revealed moderate bilateral conjunctivitis with conjunctival hyperemia and clear, serous tearing (epiphora). Mild blepharospasm was also present in the right eye. Eyelid conformation was normal, and the pupils appeared bilaterally symmetrical and normally responsive. The kitten's iris coloration, which was green, appeared normal bilaterally. Due to the presence of conjunctivitis, a thorough ophthalmic examination was warranted. Using a direct slit-beam for evaluation, the left cornea and anterior chamber appeared normal. A slight increased opacity was evident focally and centrally in the right cornea, but no other abnormalities were noted and the anterior chamber was clear. A limited fundic examination was performed using direct ophthalmoscopy and revealed no abnormalities. Strabismus, nystagmus,

ptosis, symblepharon, and enophthalmos were all absent. The kitten appeared visual on the basis of a strong visual tracking response when a cotton ball was tossed.

Moderate clear nasal discharge was present from both nostrils. Nasal congestion was audible but both nostrils were patent. Mild tan ceruminous debris was present in both ears, but no signs of inflammation or pruritus were evident, and the tympanae appeared intact. No self-trauma to the ears was apparent. Oral examination was unremarkable with no lingual or palatal ulcers and an intact palate visualized. Deciduous teeth appeared normal and were fully erupted; no adult teeth were present. The peripheral lymph nodes were normal in size and shape. Abdominal palpation revealed loops of bowel of normal thickness and size. The abdomen was soft and relaxed during palpation and the kitten displayed no indication of discomfort. The hair coat appeared dull and slightly soiled with no areas of alopecia, while the whiskers were universally short measuring only a few millimeters in length. The skin appeared normal with no wounds, injuries, or external parasites apparent. Both testicles were readily palpable in the scrotum. The kitten was ambulatory, and no orthopedic or neurologic deficits were evident.

The patient's body language remained neutral during the examination, and he remained calm and tractable during handling. The kitten ate a small amount of highly palatable canned food[d] when offered. Lifting and carrying caused no change in the kitten's behavior, and once in the cage, the kitten chose to remain exposed in the center of the enclosure, rather than hiding in the box provided. Despite normal mental status and apparent lack of fear, the patient exhibited no affiliative or social contact seeking behavior with handlers during the physical examination and initial care.

The patient's age was estimated at six weeks based on the presence of fully erupted deciduous teeth, the absence of adult teeth, developmental status with fully coordinated

ambulation, green iris pigmentation, and body weight. Deciduous teeth are fully erupted by four weeks of age, while permanent teeth are not present until 12 week of age. Kittens are ambulatory by a similar age, with motor coordination skills increasing by approximately six weeks of age. Eye color in newborns is blue and typically persists until six weeks of age. Normal weight gain for pediatric kittens is commonly estimated at 0.5 kg per month, suggesting an age of four weeks for this kitten. However, this estimate can be impacted significantly by nutritional and hydration status as well as body condition, particularly in young kittens.

Based on the history and physical examination abnormalities, the problem list for this patient included nasal and ocular signs consistent with feline upper respiratory disease, dehydration, poor body condition, unthrifty hair coat, mild ceruminous aural discharge, early maternal separation, and singleton status. The constellation of clinical signs including conjunctivitis, corneal opacity, ocular discharge, and nasal discharge were consistent with an upper respiratory infection with the primary differentials of FHV-1 and *C. felis*. Other etiologies less likely to be primary causes of these signs but possible as co-infections included FCV, *M. felis*, *Bordetella bronchiseptica,* and *Streptococcus* spp.

FeLV was also a significant co-pathogen differential with the potential to exacerbate all abnormal physical examination findings. Non-infectious causes of nasal and ocular signs in this patient were much less likely but included facial trauma, congenital nasal septal defect or nasopharyngeal polyp, and nasal foreign body. Fungal infection was extremely unlikely given this patient's signalment and geographic location. Primary differentials for the right ocular blepharospasm included corneal ulceration, ocular foreign body, conjunctivitis, and keratitis associated with feline respiratory disease.

The mild dehydration detected on physical examination was most consistent with the patient's history of being without access to food or water at least overnight and with previous environmental exposure. Due to the kitten's young age, dehydration could develop and become clinically significant more rapidly than in an adult cat. The concurrent presence of upper respiratory disease was likely also contributing to increased fluid loss and potentially to decreased intake. There was no indication of fluid loss by other routes based on the physical examination although the need for ongoing monitoring of abnormal outputs, such as vomiting or diarrhea, was apparent.

Like dehydration, loss of body condition can also occur quickly in a young kitten. Recent separation from maternal caregiving in the outdoor environment certainly would have been adequate to explain the patient's underweight body condition, especially given that malnutrition is an extremely common finding in young kittens that are delivered and raised by free-roaming queens. Other likely differentials included poor quality diet, inappetence secondary to upper respiratory disease, and malabsorption due to intestinal parasites. Congenital anatomic or physiologic malabsorption disorders were much less likely but would require reconsideration if the patient failed to gain weight in the face of a good appetite and a high quality diet, or if diarrhea was noted. Physical examination did not suggest other systemic disease.

The presence of an unthrifty hair coat in this patient warranted caution. While inadequate nutrition, exposure, and lack of recent maternal care were the most likely causes, dermatophytosis must remain a consideration for any shelter cat with a compromised hair coat due to the significant risk of transmission of this pathogen to the shelter population. Dermatophytosis exposure to other cats in the shelter and the zoonotic risk to shelter staff, visitors, and potential adopters could have catastrophic implications for the shelter. The three

dermatophytosis etiologies of concern for cats in this setting were *Microsporum canis*, *Microsporum gypseum*, and *Trichophyton* species, providing a clear indication to definitively assess this patient for their presence. External parasites including fleas and lice would be another primary consideration for a poor quality hair coat, but none were seen on physical examination and ectoparasites are rare in this shelter's geographic region. The mild aural discharge was attributed to ceruminous debris in the ear canals without evidence of underlying otitis. However, given the patient's young age and suspected history of outdoor exposure, the ear mite species *Otodectes cynotis* was considered even in the absence of pruritus particularly due to the risk of contagion to other cats. The shortened whiskers were highly suggestive of barbering, which may occur during grooming by a mother cat, and therefore consistent with recent maternal care.

An important component of this patient's problem list was the risk of socialization deficits caused by early maternal separation and its implications for normal social development. This was confounded by the fact that the kitten presented as a singleton, although it is unknown if the kitten had also been separated from littermates as well. The kitten demonstrated the ability to ingest canned food during the physical examination and, while monitoring future nutritional status would be important, developmental indicators were consistent with the kitten's ability to survive without commercial milk replacement supplementation. Of greater urgency was the prospective lack of socialization typically provided for felines by the mother and littermates. The evidence of recent maternal care found on physical examination and the tolerance to handling were favorable indicators that the kitten had previously received socialization to felines and had not developed fear of humans. While the patient was not considered feral or under-socialized at intake, he was in a crucial state of behavioral development (i.e., the sensitive period for socialization). The high risk of the development of social and emotional problems without the

support of maternal care and littermate interactions, as well as regular positive human contact, warranted key consideration in medical decisions in this case. The fact that the kitten required isolation and special biosecurity precautions to prevent disease transmission compounded these risks.

Initial diagnostic testing began with FeLV testing. Blood was collected via jugular venipuncture for an in-clinic FeLV antigen test[e], which yielded a negative result. Determining the patient's FeLV status immediately was crucial as it determined the practicality of further resource investment. The patient was at increased risk of FeLV infection based on young age and compromised health status. A positive result would have precluded future adoptability at this shelter and resulted in euthanasia per the shelter's policy.

Based on the blepharospasm in the right eye which was detected during ophthalmic exam, further evaluation was warranted. Following administration of topical proparacaine[f], a moistened cotton swab was used to exteriorize the nictitating membrane. The conjunctival lining was inflamed but no foreign body was present. Next, fluorescein dye[g] was applied topically to both corneas. A focal light beam through a blue cobalt filter revealed a pinpoint area of fluorescein dye retention in the center of the right cornea where missing epithelial cells exposed the corneal stroma. No stain uptake occurred on the left cornea. The presence of a small superficial corneal ulcer increased the suspicion for FHV-1.

Given the urgency of establishing the dermatophytosis status of the patient, a thorough dermatologic examination was performed with an ultraviolet Wood's lamp in a darkened room. No evidence of fluorescing hair shafts was found. Although most cases of *Microsporum canis* fluoresce with a Wood's lamp, some cases fail detection with this method particularly when other dermatophyte species are involved. Therefore, a trichogram was performed by plucking a

sample of hairs with a hemostat from a variety of locations on the patient and applying them to a microscope slide with a drop of mineral oil. Microscopic examination revealed no indication of fungal distortion of the hair shafts. Hair shaft morphology was intact with a distribution of hairs in both anagen and telogen phase. Based on these findings, suspicion for dermatophytosis was considerably reduced in this patient, but a fungal culture is considered the gold standard screening test. Therefore, a dermatophyte test medium culture plate[h] was inoculated with a toothbrush rubbed vigorously over the kitten's entire coat. The culture plate was placed in an incubator at 25.5 degrees Celsius for daily monitoring for up to three weeks.

To rule out the presence of ear mites, a sample of ceruminous debris was obtained from each ear canal with a cotton-tipped swab and applied to a microscope slide with mineral oil. Microscopic examination revealed no evidence of mites. No further diagnostics or treatment were indicated.

An in-clinic fecal flotation was justified in this case not only because internal parasites may have been contributing to the kitten's poor health status but also due to the risk they could pose to the shelter population or staff if zoonotic. The presence or absence of normal stool had not yet been established in this patient, but the presence of dehydration and poor body condition in the context of the patient's young age warranted the small resource investment for this test. The presence of parasites upon examination could have altered the routine endoparasiticide protocol employed; however, microscopic examination of sodium nitrate flotation[i] supernate revealed no parasite ova. Therefore, no specific treatments were indicated beyond administration of routine broad spectrum anthelmintics.

The revised problem list after initial diagnostic testing included upper respiratory disease most consistent with an infectious etiology, right corneal ulceration, poor body condition paired

with mild dehydration and attributed to malnutrition and exposure, unthrifty hair coat, early maternal separation, and current singleton status. Based upon these findings, the kitten received an Asilomar classification of treatable-rehabilitatable. The challenge underpinning this case was apparent: infectious disease concerns remained and yet housing in isolation was a risky option for several reasons. First, definitive testing and time would be required to determine the precise etiology(s) of the respiratory infection, which was necessary to establish whether or not the inciting pathogen(s) were already endemic in the shelter population and to quantify the potential risk of introducing a novel pathogen. Additionally, the risk of dermatophytosis, although low based on the results of initial diagnostics, remained an important consideration. Simultaneously, the kitten would require intensive socialization involving close contact with humans on a daily basis to ensure future adoptability after investment of diagnostic and treatment resources.

Establishing the etiology of the upper respiratory infection became crucial to the future management of this case. A diagnosis of FHV-1 would suggest that a short stay in foster care for patient treatment and socialization would likely be adequate for patient care, allowing rapid return to the shelter for adoption without creating a risk to population health. This is because FHV-1 is considered endemic in random source cat populations and strain variation is not a concern with this virus. In contrast, a diagnosis of *C. felis* would require an extended stay in foster care for treatment over the course of at least four weeks. Based on the resource investment that was implicit in the care of this kitten regardless of diagnosis, but significantly greater with *C. felis*, respiratory PCR testing was justified and conducted. Conjunctival and oropharyngeal swabs were collected and submitted as a pooled sample for a feline respiratory disease PCR panel[j] at an outside reference laboratory. Results were not available for four days due to

laboratory turn-around time over a weekend and a holiday. Meanwhile, the initial treatment and housing plan had to be formulated in the absence of diagnostic results.

The initial treatment plan for the kitten on the day of intake included provision of preventive care, correction of dehydration, and specific treatment for respiratory and ocular disease. In accordance with the shelter's standard intake procedures for kittens under 20 weeks of age, a parenteral multivalent modified live vaccine[k] against feline panleukopenia virus, FHV-1, and FCV was administered subcutaneously in the right front leg following sample collection for PCR. Broad spectrum anthelmintic treatments were administered including pyrantel pamoate at a dosage of 20 mg/kg PO once and ponazuril at a dosage of 50 mg/kg PO q24 hours for three days. No topical parasiticide was applied due to the rarity of fleas in the shelter's geographic region and the absence of indication based on physical examination findings.

Based on the mild dehydration noted on physical examination, subcutaneous fluids were warranted and adequate to correct this initial deficit as long as the patient maintained adequate intake to balance ongoing losses. Fluids were calculated as 0.55 kg (weight) X 0.055 (estimated dehydration) = 0.03 L = 30 mL. Therefore, 30 mL of a warmed balanced electrolyte solution[l] were administered subcutaneously in the intrascapular region. This treatment was meant to correct the kitten's existing fluid deficit, while appropriate, regular feeding and free choice access to water would hopefully allow the kitten to maintain hydration. At this kitten's age, fluid requirements are generally higher than for adult cats because of higher total body water content, greater body surface area to weight ratio, higher metabolic rate, and higher urine output. For this reason, the kitten's hydration status was reassessed approximately six hours later. Palpation revealed that the fluids had been absorbed, and the kitten's mucous membranes were moist and skin turgor was normal. The kitten was again observed eating a small portion of canned food.

Due to the suspicion for *C. felis* and the delay of four days in obtaining diagnostic test results, oral antibiotic treatment was initiated with an oral suspension doxycycline[m] dosed at 10 mg/kg q24 hours PO. Topical erythromycin ophthalmic ointment[n] was applied q6-8 hours OU for seven days.

Housing for this kitten pending diagnosis was problematic due to the infectious disease risk posed both to the shelter population by this patient and to this pediatric patient by the population. The kitten's clinical signs of moderate conjunctivitis, blepharospasm, corneal ulceration, and unthriftiness differed significantly from the typical presentation of this shelter's cats with endemic respiratory disease including clear ocular and nasal discharge with minimal ocular pathology. Although the kitten was subject to a five-day stray hold due to intake through the night drop kennel, shelter policy allowed animals under eight weeks of age to enter foster care immediately upon admission for the duration of their stray hold. A medically trained foster home was available, and the kitten was placed there pending diagnostic test results and future treatment plan formulation. Biosecurity protocols were followed in the foster home since infectious and potentially zoonotic diseases remained differentials. These included the following: wearing gloves and washing hands when handling the kitten, keeping the kitten separate from other cats and confined to a small area amenable to cleaning and disinfection, and limiting contact with immunocompromised individuals. The foster caregiver was counseled to balance these protocols with provision of regular positive social contact with the kitten as much as possible.

The patient was presented to the shelter for a scheduled recheck three days later. On physical examination, the kitten was bright, alert, and responsive. Mucous membranes were pink and moist, the patient appeared adequately hydrated, and body weight increased to 0.64 kg. This

weight gain of 0.09 kg since intake reflected normal hydration and weight gain consistent with clinical improvement. The foster caregiver reported that the kitten's appetite gradually improved over the past few days for a warmed highly palatable commercial canned kitten food[o] offered every four to six hours. In contrast, the kitten displayed little interest in dry commercial kitten food[p]. Ophthalmic exam revealed mild conjunctivitis and epiphora bilaterally which appeared improved from the previous examination. The right ocular blepharospasm had resolved. Fluorescein dye application showed no stain retention indicating resolution of the corneal ulcer. Mild clear nasal discharge was present and occasional sneezing was observed. Coat quality was noticeably improved. No suspicious growth had occurred on the dermatophyte test medium, and daily monitoring continued. The remainder of the physical examination was unremarkable. Behavioral findings remained unchanged from the previous examination. Although the kitten was shy and withdrawn during physical examination at the shelter, the caregiver reported increasingly affiliative behaviors at home.

Based on respiratory PCR panel results (Table 1), the upper respiratory signs were attributed to co-infection with *C. felis*, *M. felis,* and FCV pathogens. FHV-1 was present at low levels consistent with latent infection suggesting that its contribution to the current clinical signs was minimal; however, interpretation of quantitative FHV-1 PCR is not always absolute and this may have represented early or resolving infection. The ocular surface pathologies in this case, including superficial corneal ulceration and conjunctivitis, also could have been associated with *C. felis*, *M. felis*, and/or FCV infection. These results did not eliminate corneal trauma as a possible inciting cause; regardless, the exact etiology of the ulceration was not clinically important as the ulcer had already healed.

Table 1. Serial Feline Upper Respiratory Disease PCR Test Results

Test	Day 1	Day 16	Day 33
Chlamydophila felis	Positive	Negative	Negative
Feline Calicivirus	Positive	Positive	Positive
Feline Herpesvirus 1	Positive	Negative	Negative
FHV-1 Quantity (thous/swab)	3,690	n/a	n/a
FHV-1 Interpretation (below 38,000: latent)	Latent	n/a	n/a
Bordetella bronchiseptica	Negative	Negative	Negative
Mycoplasma felis	Positive	Negative	Negative

The most crucial result associated with the respiratory PCR panel was the identification of *C. felis* infection. The diagnosis of *C. felis* directly impacted the course of treatment: the kitten would require a minimum 28-day course of doxycycline treatment. The kitten was discharged and returned to the care of the foster caregiver with the following instructions: 1) continue administration of doxycycline as directed with adjusted dosage based on the kitten's weight gain, 2) continue erythromycin eye ointment topically OU q12 hours for 7 days, 3) continue the current biosecurity protocols while providing as much positive social contact as possible, and 4) return for another recheck in one week.

The kitten was presented for recheck examination one week later (day 10). The foster caregiver reported that the kitten was eating commercial dry kitten food well and showing affiliative behaviors in the home. On physical examination, the kitten was bright, alert, and hydrated. Body weight was 0.68 kg, which represented a weight gain of 10-15 grams per day and was appropriate in a kitten of this age. Physical examination showed almost complete resolution of clinical respiratory signs: the conjunctivitis had resolved, no nasal or ocular discharge was present, and only occasional sneezing was observed. The patient again tolerated handling, but remained reserved and did not seek social interaction. No suspicious growth had occurred on the dermatophyte test medium, and daily monitoring continued. The foster caregiver was instructed to discontinue the erythromycin eye ointment. The doxycycline was continued, and follow up examination was again scheduled in one week.

Recheck at day 16 revealed continued clinical improvement. The weight of 0.95 kg and the assigned ideal body condition score of 5/9 placed the kitten within normal parameters for the estimated age of eight weeks. No nasal or ocular signs were present. The hair coat was full,

glossy, and healthy. The kitten allowed handling, but displayed the inclination to hide in the carrying crate.

When questioned about the kitten's behavior at home, the foster caregiver indicated that the kitten displayed friendly, outgoing, playful behavior, but was confined to a small bathroom per biosecurity protocol. While the caregiver provided a rotation of interactive toys and engaged in multiple play, petting, and positive interaction sessions daily, the kitten had no exposure to other people, animals, or environmental stimulation. In assessing the patient's overall progression toward adoptability, another assessment weighing medical versus behavioral health was made. While antibiotic treatment needed to continue for at least an additional two weeks, establishing that the kitten was no longer shedding *C. felis* would allow greater laxity in biosecurity protocols and permit more intensive socialization. Therefore, conjunctival and oropharyngeal swabs were submitted for a second feline respiratory PCR panel[h]. Following sample collection, the second vaccine[i] against feline panleukopenia virus, FHV-1, and FCV was administered subcutaneously in the right forelimb, and pyrantel pamoate[j] was administered at a dose of 20 mg/kg PO. The kitten was discharged to the foster caregiver to continue the current treatment plan pending test results.

Two days later, the PCR test results (Table 1) were received and documented that shedding of *C. felis* had ceased; furthermore, the dermatophyte test media revealed no suspicious growth on day 18 of culture. Based on this information, biosecurity protocols for this patient were relaxed to allow handling without gloves and access to porous surfaces in the household including carpet and furniture. The kitten was transferred to a new foster home that had no other cats and could transition him to access the full household, with daily stimulation with new experiences, supervised exposure to dogs, and human visitors of a range of ages. Caregivers

were instructed to wash hands after handling the kitten and avoid contact with the very young, elderly, or immunocompromised. On day 21, the foster caregiver was notified that there was no growth on the DTM media, definitively ruling out dermatophytosis. The caregiver reported that the kitten was continuing to do well.

After 33 days in foster care, the approximately 11-week-old kitten returned to the shelter. The kitten weighed 1.2 kg with a body condition score of 5/9, reflecting normal weight gain for a kitten of this age. Physical examination revealed no ocular or respiratory pathology. Behavioral evaluation demonstrated a friendly, outgoing, social kitten with excellent cage presentation and interaction. Samples were collected for PCR testing[h] to confirm complete clearance of *C. felis*. A vaccine[i] against feline panleukopenia virus, FHV-1, and FCV was administered subcutaneously in the right forelimb, and pyrantel pamoate[j] was administered at a dose of 20 mg/kg PO once. The kitten was scheduled for neuter surgery later in the week pending test results.

Test results received later that week confirmed clearance of *C. felis* (Table 1). The kitten returned to the shelter for neuter surgery and microchip placement[q] and was moved to the adoption floor following recovery. Adoption occurred one week later after a total of 43 days of shelter care, at which time the kitten's estimated age was approximately 12 weeks. A rabies vaccine[r] was administered subcutaneously in the right hind leg at the time of adoption in accordance with local and state laws which mandate a minimum vaccination age of 12 weeks. The patient was adopted along with another shelter kitten to the same home, and no problems were reported during a telephone follow up call conducted one week post adoption. Three months after adoption, neither cat had been returned to the shelter nor had post-adoption medical or behavior assistance been requested.

The prevalence of clinical feline upper respiratory infections in the shelter was typically low at 10%, excluding peak kitten season around May when the large population of young kittens resulted in a higher prevalence. The findings in this case stimulated interest in better understanding what pathogens were present in the shelter cat population. Sample surveillance testing was performed at the time of the case to establish the endemic upper respiratory pathogens in comparison to those carried by the kitten. Respiratory PCR testing[h] was performed on four cats with acute typical URI (Table 2). The results showed FCV in two of the four tested cats but no other pathogens.

Discussion

This case of *C. felis,* FCV, and *M. felis* in a six-week old kitten demonstrates the opportunities and challenges involved in managing infectious diseases in a young animal in the context of an animal shelter. The decision to treat an unowned underage kitten with significant clinical disease requiring a prolonged course of treatment and posing an infectious risk to the population requires careful consideration. Standard outcome options available for this kitten at many animal shelters could include treatment at the facility, treatment in foster care, transfer to a rescue group, or humane euthanasia. Many shelter and community specific factors determine the most appropriate course of action: diagnostic and treatment resources available, clinical features of the disease, time of year, availability of skilled foster homes for treatment, ability to address the kitten's socialization needs, and overall shelter performance and community expectations. The decision made in this case to treat the kitten in foster care considered all of these factors.

This kitten presented to the animal shelter with respiratory disease, which creates a different dilemma than managing routine a shelter-acquired feline upper respiratory infection. While the clinical course and expected response to treatment for infections acquired at the shelter

Table 2: Upper Respiratory Disease PCR Test Results for Cats with Shelter Acquired URI

Test	Cat #1	Cat #2	Cat #3	Cat #4
Chlamydophila felis	Negative	Negative	Negative	Negative
Feline Calicivirus	Negative	Negative	Positive	Positive
Feline Herpesvirus 1	Negative	Negative	Negative	Negative
FHV-1 Quantity (thous/swab)	n/a	n/a	n/a	n/a
FHV-1 Interpretaion	n/a	n/a	n/a	n/a
Bordetella bronchiseptica	Negative	Negative	Negative	Negative
Mycoplasma felis	Negative	Negative	Negative	Negative

is typically predictable, based on past experience, a sick animal entering from the community with an unknown history of exposure could carry a novel pathogen not already endemic in the shelter population. At this shelter, feline upper respiratory disease typically manifested as mild sneezing with ocular and nasal discharge in adult cats two to four weeks after intake, and resolved within ten days of isolation. Complications of fever, inappetence, oral ulceration, and ocular surface lesions were rare. Surveillance testing demonstrated FCV infection in the few cats identified with URI at the time of the kitten's admission. In contrast, the kitten had a very different clinical presentation with conjunctivitis, corneal ulceration, and unthriftiness present at intake that represented a possible biosecurity concern to the shelter's population. Introduction of a non-endemic pathogen such as *C. felis* could have compromised the shelter's ability to treat shelter-acquired upper respiratory infections efficiently and successfully.

The decision to conduct respiratory PCR testing on this patient was made after careful consideration since such testing is cost prohibitive for routine intake processing of sick animals. The physical examination and initial diagnostics showed no findings that would impact the kitten's prognosis. Resources were in place to care for the kitten as discussed below. The outcome of PCR testing would have a direct impact on the treatment plan if pathogens were identified that would require a longer course of treatment or more caution in bringing the kitten back to the shelter. Although primary infection with FHV-1 was a top differential given the kitten's age and ocular signs, the concern for *C. felis* also justified the resource expenditure for PCR testing.

Diagnostic test selection in this case was based on the highest yield option. The respiratory PCR panel provided information on a variety of pathogens simultaneously while antigen or antibody testing for *C. felis* could have required further testing with a similar

turnaround time from the laboratory if negative and would not have provided information on co-pathogens if positive. The infection was also likely acute, increasing the possibility of a false negative result with antibody testing. While examining cytology from a conjunctival impression smear could have increased the suspicion of *C. felis* with less time and expense, it also would not have given the full clinical picture of co-pathogens. Although the decision to start empiric antibiotics in treating feline upper respiratory infections while awaiting diagnostic test results is fraught with controversy, it was justified in this case. The level of clinical suspicion for *C. felis* was high, waiting for a definitive diagnosis would have extended the overall time required for treatment in foster care, and other bacterial infections considered as differentials, including *M. felis* and *Bordetella bronchiseptica*, are also susceptible doxycycline.

Determining the retroviral infection status of the patient was important in evaluating whether to invest further resources in treatment. Cats testing positive for FeLV were not made available for adoption at this shelter due to the rarity of adoptive homes willing to take these cats which had historically led to long lengths of stay in the shelter resulting in compromised welfare. Euthanasia was considered the only outcome option for cats testing positive for FeLV if they could not be returned to their original owner. This patient's negative FeLV test on intake did not preclude the potential for recent infection not yet detectable; the kitten's adopter received standard information provided to all cat adopters at this shelter about retroviruses and the recommendation to follow up with their primary care veterinarian to discuss repeat retroviral 30-60 days after adoption. Placing two unrelated kittens into the same home prior to confirming their infection status with repeat testing inferred some risk of potential exposure; however, given the initial negative test for both kittens, their excellent health at the time of adoption, and the low prevalence of infection among clinically healthy young animals in the shelter's geographic

region, the risk was small and was further mitigated through adopter education and follow-up recommendations.

The decision to test only for FeLV and not FIV is contrary to best practice guidelines to determine the retroviral status of cats entering a new home. This was a resource allocation protocol that reflected the significantly higher cost of the in-clinic combination FIV/FeLV tests compared to tests for FeLV alone. The low FIV prevalence in the shelter's geographic area among clinically healthy cats would result in considerable cumulative cost per positive test.

In contrast, clinically ill adult cats at this shelter were tested for both FIV and FeLV. The potential interference of maternal antibodies would have made a positive test result in this young patient ambiguous and required retesting at intervals until the patient was six months old to confirm the diagnosis or establish that no infection was present. The outcome of the FIV test would not have impacted the decision to initiate immediate treatment for the kitten, thus testing for FeLV alone was justified. As with FeLV, all cat adopters were advised to follow up with their primary care veterinarian to discuss FIV testing prior to co-mingling the newly adopted cat with felines already in the home.

Dermatophytosis screening was another key component in quantifying the risk and resources necessary to treat this patient. The shelter lacked the housing, staff, biosecurity, and enrichment components needed to treat dermatophytosis on site while maintaining intake and adoption capacity. An outbreak within the shelter's population would have required closure of the shelter for extended isolation, quarantine, and treatment protocols at significant cost, damaged public perception, and reduced ability to serve the community. The combination of Wood's lamp screening of all cats at intake and culture via dermatophyte test media of any cats

with suspicious lesions or an unthrifty hair coat reduced the risk of introducing the fungal pathogen into the on-site population.

A key consideration in determining whether to proceed with treatment of this kitten was housing placement. Keeping the kitten in isolation at the shelter pending the results of the respiratory PCR panel would have placed other cats undergoing treatment for an upper respiratory infection at risk of exposure to a novel pathogen. Housing the kitten in a separate room without any other cats may have been an option at this shelter in the absence of an immediate foster home option but biosecurity would have remained a concern. Likewise, the kitten was at high risk of acquiring illness in the shelter, particularly feline panleukopenia virus, given his young age, unknown vaccine and maternal antibody status, and compromised physical condition. While some medical monitoring may have been easier in the shelter with medical personnel on site, close oversight of appetite, subtle changes in condition, and intensive nursing care are best provided in a medically trained foster home.

Once the diagnosis of *C. felis* was made and the four week length of treatment determined, housing the kitten in the shelter became even less desirable. From a biosecurity standpoint, the risk of transmission between singly housed cats is relatively low with appropriate hand hygiene; however, with the general assumption that all cats in upper respiratory isolation have been exposed to the same pathogens, it would be necessary to implement stronger precautions for staff after handling this kitten including changing gown and gloves and washing hands before contacting other cats. Housing the kitten in a separate room alone would permit more consistent biosecurity protocols but would reduce housing capacity and flexibility in the shelter for at least four weeks. Housing off-site is far preferable from a biosecurity perspective.

The overriding justification for selecting foster care was the socialization needs of this kitten. At six weeks of age, his critical socialization window necessitated frequent handling and positive interactions with humans multiple times per day. Isolation housing creates barriers to handling including the need for gowning and gloving and restricted access for volunteers. Human interaction occurs during feeding, cleaning, and medicating when staff have little extra time to spend on petting, positive handling, and playing. The risk is grave that a kitten of this age could quickly associate human handling with stressful daily events, and an association made during the socialization period can be difficult to counteract as the kitten enters adolescence. This association can manifest as fear, shyness, overstimulation, or aggression toward humans. Extra time required to socialize him after his course of treatment would prolong his length of stay in the shelter system and absorb more resources. A worst case scenario for this kitten would be to invest in his medical needs at the expense of his behavioral needs leaving him with impaired adoptability after months in the shelter.

The time of year had a direct impact on the availability of resources to invest in this kitten. He entered the shelter during September when few other kittens were incoming, in contrast to the late spring and summer months when the shelter encountered significant numbers of kittens admitted daily. The overall census of adult cats at the shelter was high, but few kittens were housed either in the shelter or in foster care. Resources for felines including staff and space were at a premium in the shelter making the prospect of committing a cat to long-term housing in the shelter building even less desirable, but kittens were desired both in foster homes and on the adoption floor. Utilizing a foster home to care for one kitten for four weeks or more would have been a difficult resource expenditure to justify during the height of kitten intake in the spring and

summer; during the fall and early winter, the availability of foster homes and the demand for the kitten once healthy made this a reasonable decision.

Foster home selection for this kitten was complicated by his diagnosis and by the intensity of treatment needed. The zoonotic potential of *C. felis,* although low, required an informed caregiver willing to implement consistent biosecurity protocols, keep the kitten separated from other cats, children, and any immunocompromised individuals, and maintain good husbandry while still providing daily positive socialization. Initially, the kitten required weight monitoring, frequent feeding, and oral and topical medication multiple times daily. Foster homes are utilized regularly by this shelter to deliver medical care, and this kitten's level of medical and behavioral needs were consistent with those frequently treated through foster care.

The initial goal of foster care for this kitten was medical stabilization while laying the foundation for socialization. Serial measurement of body weight was used as an indicator of clinical improvement. The steady documented weight gain was appropriate for the kitten based on age. Measurement of body weight is one of the most important and practical parameters for monitoring the health of neonatal and pediatric kittens. A daily gain of less than seven grams is inadequate and would have indicated that feeding was inadequate or health problems were not adequately managed. Once the patient was eating well and gaining weight, the clinical ocular disease had resolved, and test results for *C. felis* by PCR were negative, the primary foster care goal shifted to behavioral support which also meant transferring the kitten to a new foster home that could address this need more effectively. As a singleton kitten, the patient required a high level of interaction and social feedback from the human caregiver to learn appropriate degrees of stimulation and methods of play.

Placing the patient with another kitten or cat at this stage would have been ideal from a behavior standpoint but remained problematic from a biosecurity perspective. Although PCR indicated no further shedding of *C. felis,* treatment needed to continue at least two more weeks with the, albeit low, risk of recrudescence in the interim. The co-pathogens that were present, particularly FCV and FHV-1, were also of concern in causing primary disease in a naïve cat including pet cats housed in the foster home or young healthy foster kittens. A foster home was located where the patient would be the only cat for the duration of treatment, and the caregiver was committed to providing intensive enrichment and behavioral support.

The larger context justifying this kitten's treatment plan encompasses the overall shelter performance and community expectations. With a live release rate of 82% for cats, the felines at risk of euthanasia in this shelter are feral or unsocial cats and those with severe medical problems or with infectious diseases that could compromise the shelter population. The shelter uses Asilomar Accord classification for intake status and is able to place all of its healthy and treatable-rehabilitatable cats through adoption or rescue. Many treatable-manageable cats are also placed. This kitten was classified as treatable-rehabilitatable based on being under the age of eight weeks and displaying clinical upper respiratory disease signs at intake. Since this shelter is able to allocate resources successfully even to many treatable-manageable animals, it is entirely reasonable to expend the resources needed to treat an animal classified as treatable-rehabilitatable.

The intake classification reflects that this community expects the shelter to allocate the resources to make this animal adoptable without doing so at the expense of animals who are healthy at intake. A less well-resourced community might classify underage kittens as unhealthy-untreatable if the standard of care among pet owners in the community would make raising

underage unhealthy kittens an unlikely occurrence. With a large foster home roster, an active volunteer program, and a significant donor base, this shelter builds community trust through transparency. The community consequently expects the shelter to invest resources in all animals with a reasonable prognosis for recovery including cases such as this kitten.

The initial PCR testing on this kitten initiated interest in characterizing the endemic pathogens responsible for the routine cases of upper respiratory disease in this shelter. This opportunity to gain insight into the health of the population and to facilitate future decisions about treatment were the impetus behind the resource expenditure on surveillance PCR testing of four additional cats. For surveillance of pathogens endemic in the general shelter population, sampling would ideally have included newly admitted cats, acutely ill cats, convalescing cats, and long term residents. Resource limitations meant that only a subset of these cats could be tested and those selected were four cats acutely ill with the typical mild disease acquired at the shelter. Test results may have been affected by prior vaccination and/or antibiotic administration in these patients. The results showing only calicivirus do not preclude the presence of other pathogens not detected due to inadequate sampling or the timing of sampling; however, these results provide evidence for focusing upper respiratory infection prevention efforts on biosecurity, decreased cat density, and stress reduction.

Summary

This case report of the diagnosis and management of *C. felis* demonstrates the challenges in treating this infectious disease in a shelter kitten. The presence of co-pathogens, duration of time required for treatment, and population considerations can complicate efficient allocation of resources. Use of trained foster homes allowed this kitten's medical and behavioral needs to be met without compromising the other animals in the shelter's care. Balancing the priorities of

socialization and biosecurity for shelter animals is possible through veterinary oversight in collaboration with innovative placement options and community support.

Endnotes

[a]Accel® Concentrate, Ogena Solutions, LLC, Stoney Creek, Ontario, Canada.

[b]Strongid® T Suspension, Zoetis, Inc., Kalamazoo, Michigan.

[c]Marquis® (15% w/w ponazuril) Antiprotozoal Oral Paste, Bayer Animal Health, Shawnee Mission, Kansas.

[d]Prescription Diet® a/d® Canine/Feline Critical Care, Hill's Pet Nutrition, Inc., Topeka, Kansas.

[e]WITNESS® FeLV Antigen Test Kit, Zoetis, Florham Park, New Jersey.

[f]Proparacaine Hydrochloride Ophthalmic Solution, USP 0.5%, Akorn, Inc., Lake Forest, Illinois.

[g]Bio-Glo, HUB Pharmaceuticals, LLC, Rancho Cucamonga, California.

[h]DermatoPlate®, VetLab Supply, Palmetto Bay, Florida.

[i]Fecasol®, Vetoquinol, Fort Worth, Texas.

[j]IDEXX Feline Upper Respiratory Disease (URD) RealPCR Panel, IDEXX Reference.

[k]Fel-O-Guard® Plus 3, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, Missouri.

[l]Lactated Ringer's Solution, Baxter, Deerfield, Illinois.

[m]Doxycycline Hyclate Capsules, USP, 100mg, West-ward Pharmaceutical Corp., Eatontown, New Jersey.

[n]Erythromycin Ophthalmic Ointment USP 0.5%, Bausch & Lomb, Tampa, Florida.

[o]Hill's® Science Diet® Kitten Liver and Chicken Entrée, Hill's Pet Nutrition, Inc., Topeka, Kansas.

[p]Hill's® Science Diet® Kitten Healthy Development Original, Hill's Pet Nutrition, Inc., Topeka, Kansas.

[q]24 Pet Watch, Pethealth, Inc, Buffalo, New York.

[r]Rabvac 3®, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, Missouri.

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