

Clinical Case Review

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Overcoming Feline Calicivirus: Modern Treatment Methods and Comprehensive Management Strategies

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International Journal of Molecular Veterinary Research, 2024, Vol.14, No.1 doi: [10.5376/ijmvr.2024.14.0001](https://doi.org/10.5376/ijmvr.2024.14.0001)

Received: 10 Nov., 2023

Accepted: 15 Dec., 2023

Published: 01 Jan., 2024

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Preferred citation for this article:

Wang Z.L., and Lin X.F., 2024, Overcoming feline calicivirus: modern treatment methods and comprehensive management strategies, International Journal of Molecular Veterinary Research, 14(1): 1-8 (doi: [10.5376/ijmvr.2024.14.0001](https://doi.org/10.5376/ijmvr.2024.14.0001))

Abstract This study comprehensively explores modern treatment methods and comprehensive management strategies for feline calicivirus (FCV). By systematically introducing the basic characteristics, epidemiology, and significance of FCV, the research aims and expectations are elucidated. It also provides a detailed analysis of the basic biology and pathology of FCV, including virus structure, genetic diversity, infection pathways, clinical manifestations, and pathological mechanisms. In terms of modern therapeutic methods, the study delves into antiviral treatments, supportive therapy, and treatment strategies for special cases. It focuses on the types and mechanisms of antiviral drugs, the importance of supportive treatment, and considerations for treatment in cases of chronic infection and multi-cat environments. The research showcases the treatment process and outcomes of FCV through a clinical case, thoroughly discussing preventive and comprehensive management strategies. This includes the types, effects, and limitations of vaccines, preventive measures, health management of cat populations, and the importance of educating pet owners. Finally, the study summarizes the current challenges faced in treating and managing FCV and anticipates possible future treatment strategies and health management systems. The goal is to provide valuable reference for veterinary practitioners, promoting a deeper understanding and effective treatment of FCV.

Keywords Feline calicivirus (FCV); Modern treatment methods; Comprehensive management strategies; Clinical case studies; Prevention and control

Feline calicivirus (FCV) is a major pathogen affecting the health of cat populations, belonging to the Caliciviridae family, a non-enveloped, single-stranded positive-sense RNA virus. It is primarily transmitted through respiratory secretions, saliva, or direct contact, exhibiting high infectivity and widespread prevalence. Common symptoms in cats infected with FCV include oral ulcers, respiratory symptoms, fever, and even pneumonia (Wang, 2023; Gui, 2023). It is worth noting that FCV displays a certain degree of variability, adding complexity to the prevention and control of the disease.

The epidemiological characteristics of FCV in cat populations are significant. It not only affects domestic cats but also spreads widely among feral cats, posing a serious public health concern. Although most infections manifest as mild to moderate symptoms, severe cases can occur, leading to fatal diseases, especially in kittens, elderly cats, or immunocompromised cats (Hofmann-Lehmann et al., 2022). Additionally, FCV infections may result in widespread transmission within cat populations, presenting a risk to overall group health.

In the face of this challenge, researchers urgently need a deeper understanding of FCV infection mechanisms and exploration of more effective clinical treatment methods. Currently, FCV treatment relies mainly on symptom support and adjunctive therapy, lacking specific antiviral treatment methods. Therefore, research and development of new antiviral strategies, optimization of supportive treatment measures, and the establishment of comprehensive infection management and prevention systems are crucial for controlling and reducing the impact of FCV infections (Guo et al., 2022).

This study aims to comprehensively analyze the current clinical treatment status of FCV, explore modern treatment methods, and develop integrated management strategies. Through systematic literature reviews and case

analyses, we hope to provide comprehensive treatment and prevention guidance for FCV infections, reducing the negative impact on cat population health and provide scientific basis and practical guidelines for veterinary clinical practice. Through this work, we hope to contribute to overcoming FCV infection, protecting animal welfare, and public health safety.

1 Basic Biology and Pathology of FCV

1.1 Structure and genotypic diversity of FCV

Feline calicivirus (FCV), a member of the Caliciviridae family, is a non-enveloped virus with a particle diameter of approximately 30-40 nm. The genome of FCV consists of a single-stranded positive-sense RNA, with a length of about 7.7 kilonucleotides, encoding various viral proteins, including structural and non-structural proteins. One of its distinctive features is the diversity in genotypes, primarily attributed to the high error rate of the RNA-dependent RNA polymerase, leading to frequent occurrences of mutations and recombination events. This genetic diversity enables FCV to adapt to different hosts and environmental conditions, posing challenges to vaccine development and virus control.

1.2 Infection pathways and clinical manifestations

FCV is primarily transmitted through direct contact, including saliva, eye secretions, and nasal secretions of infected cats, as well as contact with contaminated objects (such as food bowls, bedding). Airborne droplets may also serve as a potential transmission route. Typical clinical manifestations include acute upper respiratory tract disease, oral ulcers, conjunctivitis, and nasal discharge. While most cats exhibit mild symptoms, in immunocompromised or unvaccinated cats, FCV can lead to more severe diseases, including pneumonia, systemic viral infections, and even death.

1.3 Pathological mechanisms

FCV infection initially occurs in the epithelial cells of the oral cavity or upper respiratory tract. Virus particles enter cells by binding to receptors on the host cell surface, initiating the replication cycle (Li et al., 2022). Viral replication results in cell damage and death, triggering an inflammatory response. Behind oral ulcers and upper respiratory symptoms lies the disruption of mucosal epithelial cells and the integrity of submucosal capillaries by the virus, leading to local tissue inflammation and ulcer formation.

In addition to direct cell damage, FCV can further contribute to tissue injury by activating the host's immune response. For instance, the infiltration of inflammatory cells and the release of cytokines can exacerbate local and systemic inflammatory reactions. Interestingly, FCV also demonstrates some immune escape capabilities, such as evading host neutralizing antibody responses through mutation (Tian et al., 2020). Moreover, the virus may induce latent infections in some hosts, leading to sustained immune activation and chronic inflammatory states (Wang, 2023).

The pathological mechanisms of FCV are diverse and complex, and the unique viral structure and genetic diversity present additional challenges for therapy development and disease control. Therefore, a profound understanding of these fundamental biological and pathological mechanisms is crucial for the development of effective prevention and treatment strategies.

2 Modern Treatment Approaches

2.1 Antiviral therapy

The primary challenge in treating feline calicivirus (FCV) lies in its high variability and the lack of specific drugs. Currently, antiviral drug use primarily focuses on two categories: nucleoside analogs and RNA polymerase inhibitors. Nucleoside analogs, such as ribavirin, disrupt the virus's replication process by mimicking nucleotides in viral RNA. RNA polymerase inhibitors, on the other hand, act by inhibiting a key enzyme in virus replication. These drugs can interfere with virus replication at different stages of the viral lifecycle, thereby alleviating symptoms (Wang, 2023).

Although antiviral drugs are theoretically effective, they face various limitations in practical application. Most antiviral drugs are designed for human viruses, and their efficacy against FCV may be limited. Additionally, the high variability of FCV may lead to the rapid development of drug resistance. Therefore, while these drugs can be part of a treatment plan, their effectiveness and safety evaluation require a comprehensive assessment of individual responses and clinical presentations.

As our understanding of FCV biology deepens, novel antiviral treatment strategies are under development. For instance, approaches based on RNA interference (RNAi) are being explored to specifically target and degrade viral RNA, representing a potentially more precise treatment method. Simultaneously, researchers are also attempting to develop more effective vaccines to prevent infection or alleviate symptoms.

2.2 Supportive therapy

FCV infection in cats often accompanies reduced appetite and dehydration symptoms. Therefore, proper nutrition and fluid support are crucial components of treatment. Nutritional support should include high-quality proteins, sufficient calorie intake, and essential vitamins and minerals. Regarding fluid therapy, intravenous or subcutaneous fluid administration may be necessary based on the specific condition of the affected cat to correct dehydration and maintain electrolyte balance.

FCV infection commonly leads to painful symptoms such as oral ulcers in cats. Appropriate pain relief measures, such as the use of opioid medications or non-steroidal anti-inflammatory drugs (NSAIDs), can significantly improve the cat's comfort (Figure 1). However, it is essential to note that the use of these drugs must be under veterinary guidance to avoid adverse reactions.



Figure 1 Oral medication

In the treatment of FCV, immunomodulators also play a significant supportive role (Kulenkova et al., 2020). For example, interferons can enhance the host immune system's response to the virus. Additionally, some immune boosters like L-lysine are believed to contribute to managing FCV infections. However, the long-term efficacy and side effects of these drugs require further clinical research for clarification.

2.3 Treatment strategies in special cases

For cats with chronic FCV infection, a comprehensive and long-term treatment plan is necessary. This may include regular clinical monitoring, personalized drug treatment plans, and strict hygiene control measures. The key to long-term management lies in regularly assessing changes in the cat's condition and adjusting the treatment plan accordingly.

In multi-cat environments, such as shelters or catteries, the complexity of FCV management significantly increases. In such situations, in addition to individual treatment for infected cats, group-level control measures must be implemented. This includes effective isolation policies, maintaining environmental hygiene, regular disinfection, and promoting a comprehensive vaccination schedule. Through these comprehensive measures, the risk of disease spread within the population can be effectively reduced.

3 Prevention and Comprehensive Management Strategies

3.1 Types, efficacy, and limitations of vaccines

Vaccines for feline calicivirus (FCV) mainly come in two types: inactivated vaccines and attenuated live vaccines. Inactivated vaccines are generally considered safer but may require boosters to enhance immune effectiveness. Attenuated live vaccines can induce a stronger immune response, but safety concerns may arise in very rare cases.

Although FCV vaccines cannot provide 100% protection, they significantly reduce the risk of infection and alleviate symptoms post-infection. The primary goal of vaccines is to prevent severe diseases caused by FCV, and their effectiveness against viral variants may be limited.

Due to the high genetic diversity of FCV, existing vaccines may not offer sufficient protection against all prevalent strains. Additionally, the effect of vaccines on clearing or reducing virus shedding in carriers is limited. Therefore, even vaccinated cats may potentially become carriers of the virus (Bergmann et al., 2019).

3.2 Control measures (e.g., isolation, disinfection)

Upon detecting FCV infection in a cat population, infected cats should be promptly isolated from healthy cats (Figure 2). The isolation period should last at least for a period of time after clinical symptoms completely disappear. Furthermore, veterinarians and cat caregivers should take appropriate personal protective measures, such as changing gloves and clothing, to minimize the risk of virus transmission when handling different cats.



Figure 2 Isolation of sick cats (Source: this hospital)

FCV is relatively stable in the environment, emphasizing the importance of environmental disinfection. Regularly clean cat living areas, including food and water containers, sleeping mats, and toys, using effective disinfectants (such as chlorides or peroxides). Care should be taken in selecting and using disinfectants to avoid health risks to cats.

3.3 Health management for cat populations

Regular health checks for cat populations (Dávila et al., 2018) and early identification and isolation of infected cats are crucial for controlling FCV spread. Besides visual and behavioral observations, routine physical examinations and laboratory tests (such as blood and urine analyses) are essential.

Ensure that each cat receives adequate nutrition and resides in a clean, comfortable environment. Sufficient nutrition and good living conditions can enhance the overall health and immunity of cats, thereby reducing the incidence of diseases.

3.4 Importance of educating pet owners

Awareness and understanding of FCV by pet owners are crucial. Through education, informing them about the modes of FCV transmission, symptoms, preventive measures, and control strategies can help minimize disease spread. Simultaneously, educating pet owners about the importance of regular vaccination for their cats is crucial. Even though vaccines cannot provide complete protection, they remain an effective means of preventing severe diseases and reducing virus transmission. Educating pet owners on how to properly care for their cats, including providing a balanced diet, maintaining a clean living environment, and scheduling regular veterinary check-ups, contributes to raising the overall health level of cats and reducing the occurrence of diseases.

By implementing these prevention and comprehensive management strategies, the spread of FCV can be effectively controlled, minimizing the impact of the disease on the health of cat populations.

4 Management of Secondary Infections

4.1 Identification and treatment of secondary bacterial or fungal infections

Secondary infection is usually the main reason for the complexity of FCV infections. These infections, especially common in cats with compromised immune systems (Hofmann-Lehmann et al., 2022), may be caused by bacteria or fungi. It is crucial to recognize early signs of these secondary infections, such as persistent fever, difficulty breathing, worsening oral ulcers, coughing, or increased eye discharge.

Upon identification of a secondary infection, immediate treatment should commence. This may involve antibiotics or antifungal therapy targeted at the specific infection. The choice of appropriate medications often relies on the results of bacterial cultures and drug sensitivity testing. Simultaneously, reinforcing supportive care, such as nutritional support and appropriate hydration, is vital for recovery.

4.2 Key complications to focus on

FCV infection can lead to severe upper respiratory complications. In the context of secondary infections, these complications may worsen, including pneumonia, bronchitis, or tracheitis. Identifying these symptoms and promptly administering appropriate treatment are key to alleviating the condition and improving chances of recovery.

FCV infections commonly result in oral issues, such as oral ulcers (Gao et al., 2022). In cases of secondary infections, these problems may escalate, causing severe pain and difficulty in eating. Maintenance of oral hygiene, along with the use of analgesics and anti-inflammatory drugs when necessary, is crucial for mitigating these complications.

4.3 Monitoring and long-term management strategies

Regular health monitoring is crucial for cats that have previously experienced FCV infection with secondary infections. This includes routine physical examinations, blood tests, and imaging studies to ensure there is no development of potential complications.

For cats with chronic symptoms or frequent recurrences, long-term management strategies may be necessary. This could involve ongoing administration of specific medications, regular veterinary visits, and special adjustments to the living environment, such as reducing sources of stress, providing high-nutrient-value food, and maintaining good environmental hygiene.

Pet owners play a crucial role in managing secondary infections. Educating them to recognize signs of recurrence, understanding the importance of disease management, and encouraging regular follow-ups and treatments as advised by the veterinarian are essential.

Through these comprehensive strategies for managing secondary infections, complications can be effectively controlled, improving the quality of life for cats. Simultaneously, it provides support and guidance to pet owners in addressing this challenge collaboratively.

5 Successful Treatment Case Study

5.1 Case description

Kangkang, a typical Chinese LiHua cat, is housed at the Hainan Tropical Agriculture Resources Research Institute. He resides in a 400-square-meter indoor space on the third floor of the institute's office building. Kangkang is a male cat, born on July 17, 2020, and has been neutered. Despite receiving complete vaccinations and regular deworming, he exhibited symptoms such as hematuria, weight loss, oral ulcers, and gingival edema on October 22, 2023. His weight decreased from 7.5 kilograms to 6.6 kilograms. Preliminary examination revealed abdominal tenderness when touching Kangkang's abdomen, and there was noticeable swelling in the oral and pharyngeal regions.

The diagnostic process involved clinical symptom observation and a five-fluorescent PCR test for feline respiratory diseases. The results indicated that Kangkang was infected with a cup-shaped virus, with a Ct value of 20.5, confirming a positive reaction.

5.2 Analysis of the treatment process

The treatment plan encompassed several aspects: Initial assessment, including a comprehensive physical examination and evaluation of vital signs and overall health. Laboratory tests, including CT scans, blood routine, urinalysis, and specific FCV detection. Clinical treatment, involving analgesic, anti-inflammatory therapy, antiviral treatment targeting FCV, and concurrent supportive care.

5.3 Treatment methods employed

Bayer Baytril Injection: Dosage of 1 mL, subcutaneous injection, once daily. Meloxicam: Dosage of 1 mL, subcutaneous injection, once daily. Zhongke Baiken Cat Interferon: 1.5 million U, subcutaneous injection, once daily. Kuru Oral Antimicrobial Spray: Oral spray, three times daily. The master of calicivirus/Lysozyme: Targeted genetic engineering, oral administration, twice daily, one capsule each time. High-nutrient wet food: To support Kangkang's overall nutritional needs.

5.4 Special management strategies

Kangkang was isolated after discharge to prevent direct contact with other pets, reducing the risk of disease transmission. Additionally, continued oral administration of the master of calicivirus for two treatment courses (8 days each) was prescribed to consolidate the treatment effect.

5.5 Prevention and management of secondary infections

During Kangkang's treatment, special attention was given to monitoring and preventing potential secondary infections. The occurrence of secondary infections was successfully avoided through regular examinations and timely treatment adjustments.

5.6 Treatment outcome

Following Kangkang's discharge on November 7, 2023, there was a noticeable improvement in his overall health. The results of the five fluorescent PCR tests for the respiratory tract conducted on December 7, 2023 were negative, indicating the success of the treatment.

5.7 Academic and clinical significance of the case

This case demonstrates the effectiveness of a comprehensive treatment approach for FCV infection in a clinical setting. It underscores the importance of early diagnosis, comprehensive treatment plans, and strict management strategies in controlling FCV infections. Furthermore, the case proves that high-risk cats, such as those with other health issues, can achieve positive treatment outcomes with appropriate care.

5.8 Insights into existing treatment strategies from the case

Kangkang's case provides valuable practical experience for the treatment of FCV infections. It serves as a crucial reference for similar cases in the future, particularly in the application of comprehensive treatment strategies, the design of individualized treatment plans, and the management of preventing secondary infections. Additionally, this case highlights the importance of communication between veterinarians and pet owners to ensure the smooth implementation of treatment plans and timely tracking of the pet's condition.

6 Summary

Feline calicivirus (FCV), as a common yet complex viral disease in cats, poses multiple challenges in its treatment and management. The widespread use of antiviral drugs has led to an increasing resistance of FCV to these medications. Current vaccines do not provide complete prevention against all FCV strains, and their effectiveness against certain variants is limited (Zheng et al., 2022). The high variability of FCV complicates treatment and prevention strategies. In multi-cat environments, managing virus transmission, reducing stress, and minimizing conflicts present additional challenges. Insufficient awareness among pet owners about FCV may result in improper disease management and treatment failures.

Despite the numerous challenges in treatment, technological advancements have introduced new therapeutic strategies and research directions for FCV. The development of gene editing technologies such as CRISPR offers possibilities for precise targeting and repairing of viral genes. Future researchers can explore novel antiviral drugs, especially those targeting FCV-specific mechanisms, to overcome existing drug resistance. Developing broader and more effective vaccines, particularly those capable of addressing various mutant strains, is essential (Lu et al., 2018). Researching new immunomodulatory methods to enhance host immune responses and resistance to FCV is also crucial. Creating comprehensive treatment strategies that integrate drug therapy, immune modulation, and optimized management measures is an avenue for exploration.

In the future, with the collaboration of technology and interdisciplinary efforts, the development and utilization of integrated health management systems seem promising. Researchers can explore the development of intelligent health monitoring tools, such as wearable devices, for real-time monitoring of a cat's health. Utilizing big data and artificial intelligence, personalized treatment and management plans can be formulated for each cat. Establishing a comprehensive platform for pet health education can enhance pet owners' disease awareness and management skills. Promoting collaboration among veterinarians, researchers, and technology developers will collectively drive the advancement of FCV treatment and prevention technologies.

In conclusion, although the current treatment and management of FCV face various challenges, there is reason to anticipate more effective control and treatment of this disease in the future, thanks to the progress in science and technology and the deepening collaboration across multiple disciplines.

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