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Clinical Presentations, Laboratory Findings, Diagnostic Imaging and Trials for Treatment in Cats with Feline Infectious Peritonitis

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ABSTRACT

Feline infectious peritonitis (FIP) is a fatal disease in cats caused by a mutated feline coronavirus. Despite advancements in antiviral therapies, diagnosis remains challenging, particularly in non-effusive forms, due to the nonspecific nature of clinical and laboratory findings. This study aimed to evaluate clinical presentations, laboratory findings, diagnostic imaging features, and treatment outcomes in cats with FIP, to refine diagnostic criteria and assess therapeutic responses to GS-441524. Thirty cats diagnosed with FIP and ten healthy controls were studied at Aleef Care Veterinary Clinic in Saudi Arabia between January 2024 and June 2025. Clinical signs, blood parameters, and imaging findings were recorded. Feline coronavirus antibody testing and imaging (ultrasound and radiography) were used for diagnosis. Case confirmation of FIP was based on a combination of clinical presentation, positive feline coronavirus antibody testing, imaging evidence of effusion or organ involvement (ultrasound and/or radiography), and, detection of antibodies against feline coronavirus in serum samples. Treatment involved oral or injectable GS-441524 over 84 days, with adjustments based on disease stage. Imaging confirmed fluid accumulation in effusive cases. Compared to healthy controls, cats with FIP showed significantly higher total protein, globulin, and bilirubin levels, and lower albumin and A/G ratio values ($P<0.05$). Following treatment with GS-441524, significant improvements were observed in serum albumin, ALT, and bilirubin levels compared with pretreatment values ($P<0.05$), while hematological indices such as hemoglobin and total leukocyte counts approached normal ranges. Statistical analysis demonstrated significant post-treatment increases in body weight and appetite scores ($P<0.01$), accompanied by normalization of temperature and biochemical parameters ($P<0.05$). GS-441524 therapy showed potential efficacy in FIP management, even in advanced disease stages. Combined clinical, laboratory, and imaging assessments enhance diagnostic accuracy. Regulatory approval and standardized access to antiviral agents are needed to ensure consistent and safe treatment.

Keywords: Biomarkers, Cat, Feline infectious peritonitis, Diagnostic Imaging, Treatment, GS-441524.

INTRODUCTION

Feline infectious peritonitis (FIP) is a severe illness in cats, triggered by a mutated form of a common feline coronavirus. While cats of any age may develop the disease, it is most often found in those younger than three years old, particularly between the ages of four to sixteen months (Pedersen et al. 2009; Felten and Hartmann 2019; Paltrinieri et al. 2021; Solikhah et al. 2024). The disease tends to emerge in settings where multiple cats are housed together, such as breeding facilities, shelters, rescue organizations, and densely populated stray cat colonies. Like other endemic conditions, FIP occurrence may vary periodically (Goodson et al. 2009). After clinical symptoms arise, the disease is almost always fatal, though a small number of cats may survive for extended periods, sometimes weeks, months, or rarely, years. Comprehensive discussions of FIP's clinical presentation are available in previous literature (Addie et al. 2009; Izes et al. 2020).

The virus responsible for FIP, feline infectious peritonitis virus (FIPV), is a mutated variant of the feline enteric coronavirus (FECV). This virus spreads easily among cats but typically causes only mild illness or remains asymptomatic (Pedersen et al. 2009). FECV is commonly found in the feces of healthy cats, especially those living in group environments, and is transmitted through contact with contaminated feces or objects such as litter boxes. Kittens generally contract the virus around the age of nine weeks (Pedersen 2014; Solikhah et al. 2024).

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During peak replication of FECV, numerous viral mutations may develop, some of which have the potential to cause FIP (Vogel et al. 2010). However, only a minority of infected cats actually go on to develop the disease. Factors such as genetics, the age at infection, and environmental stress contribute significantly to whether a cat progresses to FIP (Tasker et al. 2023).

FIP manifests in two primary clinical types: the effusive or wet form, and the non-effusive or dry form. The effusive type involves fluid accumulation within body cavities and presents with general signs like fever, apathy, difficulty breathing, and enlarged abdomen due to fluid buildup. Fluid analysis usually reveals a protein concentration exceeding 3g/dL. This form is fast-progressing and typically ends in death. The dry variant, on the other hand, evolves more slowly and features more localized, variable symptoms depending on which organs are affected (Solikhah et al. 2024). The time between initial FECV exposure and FIP symptom onset can vary, from just a few weeks to many months or even years. This window likely corresponds to the time needed for FIPV to emerge or for clinical disease to develop from a latent infection. In subclinical cases, the infection often stays limited to regional lymph nodes and may either resolve on its own or eventually evolve into FIP (Drechsler et al. 2011). Once clinical signs appear, it usually reflects an overwhelmed immune system and signals a poor prognosis. Occasionally, cats that appear to recover may relapse much later (Legendre and Bartges 2009; Solikhah et al. 2024).

At present, there is no globally licensed cure for FIP. However, GS-441524, a compound related to Remdesivir, has shown great promise. Despite not having universal regulatory approval, studies indicate it results in clinical improvement in about 90% of treated cases (Coggins et al. 2023). Both injectable Remdesivir and oral GS-441524 have been effective and are generally well tolerated. Effective monitoring of treatment should start with observing clinical changes and be followed by evaluation of lab data (Coggins et al. 2023).

Due to the high fatality rate of untreated cases, timely and precise diagnosis is vital. Veterinarians must carefully consider the patient's clinical history, age, symptoms, and results from physical and laboratory examinations when selecting diagnostic tests. Although promising antiviral therapies have emerged, their legal availability varies by country. Veterinary experts are advised to keep abreast of emerging data, clinical trial findings, and any new drug approvals (Thayer et al. 2022).

Diagnosing FIP has become more reliable due to advancements in serological analysis, clinical pathology, and molecular diagnostics such as PCR, along with immunological testing (Tasker 2018). However, identifying the disease—particularly the dry form—remains challenging because of the non-specific nature of clinical signs and the incomplete understanding of the virus's pathogenesis (Kipar and Meli 2014). Despite numerous diagnostic tools, there is still no single, standardized, and non-invasive test that can accurately distinguish FIP from other systemic feline diseases at an early stage. This lack of a dependable, accessible diagnostic approach represents a major knowledge and practical gap in feline medicine. Therefore, this study aims to establish a reliable screening process for FIP detection by integrating clinical evaluation, laboratory testing, diagnostic imaging, and treatment response analysis in affected cats, ultimately contributing to more accurate and timely diagnosis in clinical practice.

MATERIALS AND METHODS

Animals and trials for treatments

Between January 2024 and June 2025, a total of thirty cats of various breeds diagnosed with FIP were admitted to Aleef Care Veterinary Clinic in Riyadh, Saudi Arabia. Depending on whether the disease was dry or wet, the affected cats exhibited a range of clinical signs, including loss of appetite, a swollen abdomen, difficulty breathing, fever, and neurological symptoms. The treatment approach varied according to the disease's progression at the time of admission and was categorized into three stages: early, advanced, and late. In addition, a control group consisting of ten clinically healthy cats was included for comparison. These cats ranged in age from 5 months to 5 years and weighed between 2 and 5kg. All control cats were privately owned, clinically normal on physical examination, and tested negative for feline coronavirus (FCoV) antibodies using the same immunochromatographic assay described below. They were not receiving any medications and had no history of systemic illness. Blood and serum samples collected from these cats were used to establish baseline hematological and biochemical reference values for comparison with FIP-affected cats. All procedures were carried out in compliance with the ethical guidelines approved by the Ethics Committee for the Use and Care of Animals at Qassim University (QU-J-PG-2-2025-52445), adhering to the standards set forth in the Guide for the Care and Use of Agricultural Animals in Research and Teaching (FASS 2010).

For cats in the early phase of infection, treatment involved administering oral GS-441524 tablets (FIP Cure, China) at a dosage of 8–10mg/kg once daily for 84 consecutive days. Cats presenting in advanced or late stages of FIP received subcutaneous GS-441524 injections (FIP Cure, China) at a dosage of 4–6mg/kg once daily for 84 consecutive days. The oral formulation consisted of film-coated tablets, while the injectable form was supplied as a sterile aqueous solution containing GS-441524 at 15mg/mL. Dosages were adjusted based on the severity of clinical signs and body weight changes observed during treatment. The injection protocol required rotating the site daily, alternating between areas adjacent to the femur and the thoracic vertebrae, starting on the right side one day, then switching to the left the next, to minimize site irritation and enhance absorption.

Detection of feline corona virus

A sandwich-format lateral flow immunochromatographic assay was employed to detect antibodies against FCoV in serum samples. The FCoV Antibody (Ab) Test kit (Asan Pharma, Seoul, Republic of Korea) is designed for the qualitative detection of FCoV antibodies in serum, plasma, or whole blood. Before performing the assay, all materials—including samples and test components—were equilibrated to room temperature (approximately 15–30 minutes). The test strip was removed from its protective pouch and placed on a clean, flat

surface. A volume of 5 µL of serum was added to the assay solution tube and gently mixed using a capillary tube. Three drops of the prepared solution were then dispensed into the sample well of the test cassette. Results were read exactly 10 minutes after sample application. A single band at the control line indicated a negative result, while two visible bands (control and test lines) denoted a positive result. Tests showing no control band were considered invalid and repeated with a new device and specimen. While this assay provides rapid detection of FCoV antibodies, it cannot differentiate between benign FECV infection and the virulent FIPV. Therefore, serological testing alone cannot confirm a diagnosis of FIP. Given the complex pathogenesis of FIP and the high prevalence of FCoV exposure in cat populations, definitive diagnosis requires confirmation through detection of FIPV RNA using reverse transcription polymerase chain reaction (RT-PCR) from effusion or tissue samples, or by histopathological examination demonstrating characteristic pyogranulomatous inflammation. Consequently, the antibody assay in this study was used only as an initial screening tool, with confirmatory testing performed where applicable.

Collection of blood samples and analysis of hematobiochemical parameters

Blood was drawn via jugular venipuncture from both affected and clinically normal cats. Two distinct samples were collected for diagnostic purposes. The first sample was placed in tubes containing EDTA and used to perform a complete blood count (CBC), including leukocyte profile (total white blood cells and differential counts), red blood cell parameters (RBC count, hemoglobin concentration, hematocrit value, and red cell indices), and platelet count, using an automated hematology analyzer (VetScan HM5, Abaxis, USA). The second sample was transferred into plain tubes without anticoagulant to allow clotting, and the serum was subsequently separated for biochemical evaluation. This included assessing levels of total protein, calcium, blood urea nitrogen (BUN), creatinine, glucose, alkaline phosphatase (ALP), alanine aminotransferase (ALT), albumin, globulin, amylase, potassium, sodium, total bilirubin, direct bilirubin, and creatine kinase, all analyzed using the VetScan VS2 analyzer (Abaxis, USA).

Sonography and radiography of the thorax and abdomen

A 7.5MHz convex ultrasound probe (SonoScape, Sonoscape Medical Corp., China) was used to perform transcutaneous imaging of the thoracic cavity, enabling the visualization of the heart, major blood vessels, lungs, and pleural membranes. The same ultrasound system and transducer were also employed to assess the abdominal organs, including components of the gastrointestinal tract (stomach, small and large intestines), the liver, peritoneum, and structures of the urinary tract such as the kidneys and bladder. With informed consent obtained from the cat owners, samples of peritoneal fluid were collected through a free-hand, ultrasound-guided aspiration technique. These fluid specimens, along with serum samples, were stored at -20°C for later analysis. Additionally, radiographic imaging of the chest and abdominal cavities was performed in cats exhibiting the effusive (wet) form of FIP, using a Min-X-ray HF 100/30 radiographic unit (Toshiba, Tokyo, Japan).

Statistical Analysis

Data were analyzed using SPSS, version 25 (2017). For parameters measured before and after treatment within the same group of cats, the paired *t*-test was applied. Comparisons between FIP-affected cats and healthy controls were conducted using the independent samples *t*-test all results were expressed as mean ± standard deviation. A $P<0.05$ was considered statistically significant.

RESULTS

The clinical signs observed in the infected cats varied depending on whether they exhibited the dry or wet form of feline infectious peritonitis. In cases of the dry form, symptoms typically included persistent lethargy, fluctuating body temperature, reduced appetite or complete refusal to eat, weight loss, and severe body condition deterioration. Jaundice was inconsistently present, and some cats displayed coordination issues and mobility problems. Neurological symptoms were evident in certain individuals, such as impaired vision, repetitive head shaking, ataxia, circling, profound lethargy, anorexia, and irregular body temperature patterns.

For those affected by the wet (effusive) form, clinical findings included visible abdominal distension due to fluid accumulation, anorexia, elevated body temperatures reaching up to 40°C, severe lethargy, and marked weight loss accompanied by jaundice (Table 1). In cases involving pleural effusion, labored breathing and pronounced abdominal respiratory effort were recorded (Fig. 1).

Diagnosis was made using a combination of diagnostic tools and criteria, including complete blood counts, serum biochemistry profiles, positive results for feline coronavirus antibodies, and both radiographic and ultrasonographic imaging (Table 1). Hematological and biochemical test results for each individual cat are summarized in Table 1. Compared to healthy controls, cats with FIP showed significantly higher total protein, globulin, and bilirubin levels, and lower albumin and A/G ratio values ($P<0.05$). Following treatment with GS-441524, significant improvements were observed in serum albumin, ALT, and bilirubin levels compared with pretreatment values ($P<0.05$), while hematological indices such as hemoglobin and total leukocyte counts approached normal ranges. Statistical analysis demonstrated significant post-treatment increases in body weight and appetite scores ($P<0.01$), accompanied by normalization of temperature and biochemical parameters ($P<0.05$).

Fig. 2 and 3 illustrate sonographic and radiographic images of a cat diagnosed with FIP, where extensive abdominal effusion is seen. In these images, organs such as the liver, intestines, kidneys, and urinary bladder are clearly observed floating within the accumulated fluid. Clinical response to treatment was noticeable from the initial dose; affected cats began eating again and their fevers subsided without recurrence. Jaundice resolved between 14 and 30 days after treatment initiation, and ascitic fluid was no longer present after approximately one month.

Fig. 1: Different presentation of cats with feline infectious peritonitis. Abdominal distension is a characteristic feature in diseased animals with the wet form (A-F). Animals in images G and H shows progressive weight loss that accompany the ascites.

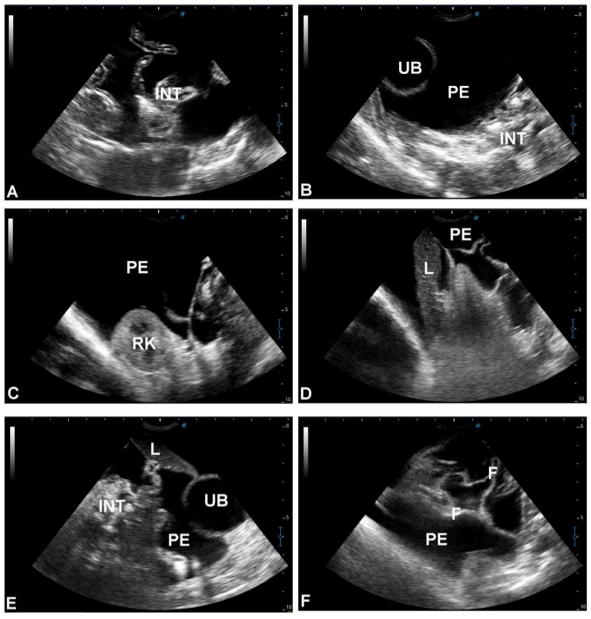

Fig. 2: Ultrasonographic findings in cats with feline infectious peritonitis. Abdominal scanning showed massive peritoneal effusions (PE). In image A, intestines are visualized floating in the PE. In image B, the urinary bladder (UB) and the intestines are found floating within the PE. The right kidney (RK) and the liver (L) are also found with the PE in images C and D, respectively. Image E shows the liver (L), urinary bladder (UB) and the intestines within the PE. Image F shows massive fibrin network with the PE.

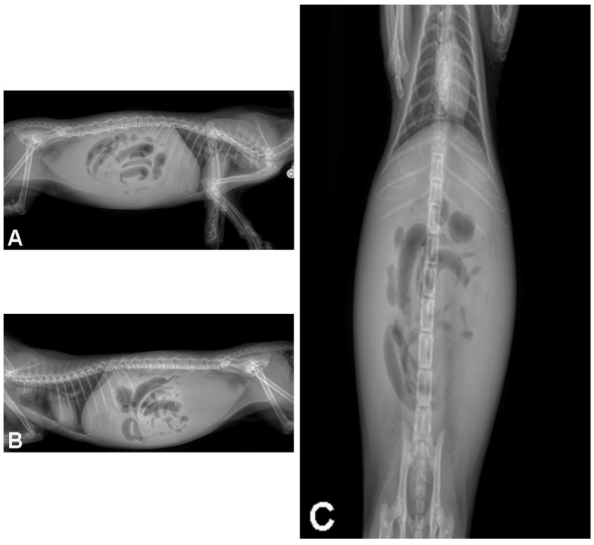

Fig. 3: Radiographs of large amount of effusion in the abdominal cavity in a cat with feline infectious peritonitis (A: right; B: left; and C: ventral view).

A total of fifteen cats successfully completed the full 84-day treatment course, showing favorable outcomes. Three of these experienced a relapse after completing therapy. Five other cats discontinued treatment after 30 days, and six received only 14 days of therapy; these six cats still showed clinical improvement and remained relapse - free. Out of 29 cats undergoing treatment,

Table 1: Age, sex, body weight, presenting complaints, diagnostic tests, hematobiochemical alteration, diagnostic imaging, response and type in 30 cats with feline infectious peritonitis

No.	Age, sex, body weight	Admission complains	Diagnostic tests	Hematology	Biochemistry	Ultrasound and X-ray findings	Response	Type
1	1 year female 4.2kg	Lethargy-loss of appetite-holding-abdominal distension-Jaundice	CBC X ray biochemistry	Low (RBC) Low (HCT) High (NEU) Low (EOS)	Low (ALP) High (TBIL) High (AMY) High (TP) High (GLOB)	Ascites	Good CBC and biochemistry all normally And ascites disappeared	Wet
2	9 months Male 1.3kg	Lethargy-loss of appetite -jaundice mild abdominal distension	CBC X ray Biochemistry ultrasound	Low (RBC) Low (HCT) Low (HGB) High (NEU) High (MONO) Low (EOS) Low (PLT)	Low (CREA) Low (BUN) High (TP) High (GOLB) High (ALT) High (TBIL) High (AMYL)	Mild ascites	Good CBC and biochemistry all normally and ascites disappeared	Wet
3	6 months female 1.8kg	Lethargy-grogginess-not eating- jaundice-abdominal distension	CBC X ray Biochemistry	Low (RBC) Low (HCT) Low (HGB) High (NUE) Low (EOS)	High (TP) High (GOLB) Low (ALP) High (TBIL)	X-ray shows ascites and abdominal soft tissue opacity	Good CBC and biochemistry are normal and ascites disappeared	Wet
4	9 months Female 2.9kg	Lethargy-grogginess-not eating- jaundice-abdominal distension	CBC X ray Biochemistry Ultrasound	Low (RBC) Low (HCT) Low (HGB) High (NUE) Low (EOS)	Low (ALP) High (TBIL) High (AMY) High (TP) High (GLOB)	X-ray and ultrasound show Increase ascites in abdominal Soft tissue opacity	Good CBC and biochemistry are normal and ascites disappeared	Wet
5	4 years Male 2.2kg	Lethargy-not eating-jaundice- abdominal distension	CBC X ray Biochemistry	Low (HCT) Low (MCV) Low (WBC) Low (LYM) Low (PLT)	Low (ALB) High (TBIL) Low (BUN) High (CER) Low (NA) Low (K) Low (TP)	X-ray shows ascites and abdominal soft tissue opacity	Bad	Wet
6	3.5 Years Female 3.6kg	Lethargy-anorexia-jaundice- abdominal distension	X ray Biochemistry	Low (WBC) Low (RBC) Low (HGB) Low (HCT) Low (PLT)	Low (CREA) High (GLOB) Low (ALKP) High (TBIL)	X-ray shows ascites and abdominal soft tissue opacity	Bad	Wet
7	2 years Male 3.6kg	Lethargy- anorexia-jaundice-Abdominal distension	CBC Biochemistry	Low (WBC) Low (RBC) Low (HGB) Low (HCT) Low (PLT)	Low (CREA) High (GLOB) Low (ALP) High (TBIL)	------	Good CBC and biochemistry all normally and ascites disappeared	Wet
8	4 months Male 1.4kg	Lethargy- anorexia-jaundice-Abdominal distension	CBC Biochemistry	Low (RBC) Low (HGB) Low (HCT) Low (PLT) High (WBC) High (NEU)	High (TP) High (GOLB) Low (ALP) High (TBIL)		bad	Wet
9	7 months Male 1.9kg	Lethargy- anorexia-jaundice-Abdominal hemorrhage	CBC Biochemistry ultrasound	HCT (L) MCV (L)	ALB (L) AST (H) DBIL (H) TBIL (H) GLOB (H) CRE (L)	Ultrasound showed ascites	good	Wet
10	2 years Female 3.1kg	Lethargy- anorexia-jaundice-Abdominal hemorrhage	CBC Biochemistry Ultrasound	NEU (H) LYM (L) EOS (L) PLT (L)	AST (H) TBIL (H) DBIL (H) GLU (H) CK (H)	Ultrasound showed ascites	bad	Wet
11	2 years Male 3.0kg	Lethargy- anorexia-jaundice-abdominal distension	Biochemistry X-ray		TP (H) TBIL (H) AMY (H)	X ray showed ascites	Good	Wet
12	7 months Male 2.1kg	Lethargy-anorexia-hydrothorax	CBC Biochemistry Ultrasound x-ray	WBC (H) NEU (H) EOS (L)	GLOB (H) CRE (L) GLU (H) UREA (L)	x-ray and ultrasound showed hydrothorax	good	Wet
13	1 year Female 1.8kg	Lethargy -anorexia-jaundice- abdominal distension	CBC	MCHC (H)			Good	Wet

14	1 year Male 1.7kg	Lethargy -anorexia-jaundice- abdominal distension	CBC Biochemistry	NEU (H) LYM (L) EOS (L) PLT (L)	Low (CREA) High (GLOB) High (TP) Low (ALP) High (TBIL)		Good	Wet
15	2 years Male 3.3kg	Lethargy -anorexia-jaundice- abdominal distension	Biochemistry		CERA (L) CA (H) GLOB (H)		good	Wet
16	6 months Male 1.6kg	Lethargy -anorexia-jaundice- abdominal distension	CBC Biochemistry Ultrasound	RBC (H) HCT (L) HGB (L) MCV (L) MCHC (L) HGB (L) LYM (L) MONO (L) EOS (L) BASO (H) PLT (L)	TP (H) GOLB (H) ALP (L)	Ultrasound showed ascites	good	Wet
17	3 months Male 1.5kg	Lethargy -anorexia-jaundice- abdominal distension	CBC Biochemistry	NEU (H) LYM (L) EOS (L) PLT (L)	Low (CREA) High (GLOB) High (TP) Low (ALP) High (TBIL)		Bad	Wet
18	1 year Female 2.6kg	Lethargy -anorexia-jaundice- abdominal distension	CBC Biochemistry	HCT (L) HGB (L) EOS (L)	CREA (L) BUN (L) CA (L) ALB (L) GLOB (H) ALP (L) TBIL (H)		Good	Wet
19	1 year Male 2.8kg	Lethargy -anorexia-jaundice- abdominal distension	CBC Biochemistry	WBC (H) NUE (H) LYM (H) MCV (L) PLT (L)	AST (H) GLOB (H) CRE (L)		good	Wet
20	9 months Female 2.0kg	Lethargy -anorexia-jaundice- abdominal distension	CBC Biochemistry Ultrasound	MCH (L) MCHC (L) PLT (L)	ALT(H) ALB (L) TBIL (H) NA (L)	Ultrasound showed ascites	-------	Wet
21	7 months Female 1.1kg	Lethargy -anorexia-jaundice- abdominal distension	CBC Biochemistry Ultrasound	HCT (L) HGB (L) MCV (L) MCHC (L) NUE (H) LYM (L) EOS (L) PLT (L)	TP (H) GLOB (H) ALP (L)	Ultrasound showed ascites	Good	Wet
22	1 year Female 1.6kg	Lethargy-emaciation-anorexia-jaundice	CBC Biochemistry	MCV (L) LYM (L) EOS (L) BASO(L) PLT(L)	CREA (L) BUN (L) TP (H) GLOB(H)	------	good	Dry
23	1 year Male 1.9kg	Lethargy-Emaciation-anorexia	CBC Biochemistry	HCT (L) HGB (L) MCV (L) MCHC (L) NUE (H) LYM (L) EOS (L) PLT (L)	ALB (L) AMY (H) TBIL (H) TP (H) GLOB (H)	------	good	Dry
24	7 months Male 1.3kg	Lethargy-Emaciation-anorexia-jaundice	CBC Biochemistry	MCV (L) LYM (L) EOS (L) BASO (L) PLT (L)	TBIL (H) TP (H) GLOB (H)	------	good	Dry
25	8 years Male 4.2kg	Lethargy-Emaciation-anorexia	CBC Biochemistry	RBC (L) HCT (L) WBC (H) NUE (H) MONO (H)	TP (H) GLOB (H) GGT (H)	------	good	Dry

26	8 years Female 4.6kg	Lethargy- Emaciation-anorexia	CBC Biochemistry	LYM (L) EOS (L) BASO (L) PLT (L)	TP (H) GLOB (H) TBIL (H)	------	Good	Dry
27	1 year Male 2.0kg	Lethargy- Emaciation-anorexia	CBC Biochemistry	PLT (L) MCHC (H)	TP (H) GLOB (H) ALP (L)	------	good	Dry
28	1 year Male 1.4kg	Lethargy-anorexia- jaundice- abdominal distension	CBC Biochemistry x-ray	LYM (L) RBC (L) HGB (L) HCT (L) PLT (L)	ALB (L) ALT (H) TBIL (H) GLU (H) NA (L) K (L)	x-ray shows abnormal hepatic echotexture and ascites	good	Wet
29	1 year Male 2.2kg	Lethargy-anorexia- jaundice- abdominal distension	CBC Biochemistry	WBC (H) NUE (H) LYM (H) MCV (L) PLT (L)	TP (H) GLOB (H) ALP (L)	------	good	Wet
30	1.2 year Female 2.4kg	Lethargy- Emaciation-anorexia	CBC Biochemistry	PLT (L) MCHC (H)	TP (H) GLOB (H) GLU (H) ALP (L)	------	Bad	Dry

Abbreviations: LYM, lymphocyte; RBC, red blood cells; HGB, hemoglobin; HCT, hematocrit; PLT, platelets, MCV, mean corpuscular volume, EOS, eosinophil, MONO, monocyte, BAS, basophil; TP, total protein; CA, calcium; BUN, blood urea nitrogen; CR, creatinine; GLU, glucose; ALP, alkaline phosphatase; ALT, alanine aminotransferase; ALB, albumin; GLOB, globulin; AMY, amylase; K, potassium; NA, sodium; TBIL, total bilirubin; DBIL, direct bilirubin; CK, creatine kinase.

24 (82.8%) recovered, while 5 (17.2%) succumbed to the disease. Among the recovered group, 3 cats (12.5%) showed relapse signs after treatment completion (Table 1). Postmortem examination could not be performed on the deceased cats, as consent was not granted by their owners.

Treatment response was classified based on clinical and laboratory outcomes. A "good" response was defined as resolution of clinical signs, including normalization of body temperature, improvement or return of appetite, disappearance of ascites or pleural effusion, and recovery of mobility and neurological function if affected. Laboratory parameters were considered improved if serum albumin increased, bilirubin decreased, and other hemato-biochemical values (total protein, globulin, A/G ratio, ALT) approached normal ranges. Overall, cats that completed at least 84 days of GS-441524 treatment with sustained improvement and no relapse were considered to have a good response. A "bad" response was defined as persistence or worsening of clinical signs, lack of improvement or further deterioration of laboratory parameters, or death during or after treatment despite therapy.

DISCUSSION

Confirming a diagnosis of feline infectious peritonitis (FIP) remains a significant clinical challenge, and any tentative diagnosis should be made with caution (Moyadee et al. 2024). In most instances, particularly with the dry (non-effusive) form, diagnosis often relies on evaluating general clinical indicators and routine lab results, which are frequently non-specific. Definitive diagnostic methods are rarely applied. Recently, advancements in machine learning have shown promise in enhancing the consistency and efficiency of interpreting clinical pathology data, thereby increasing the diagnostic potential of standard laboratory evaluations (Dunbar et al. 2024).

FIP is a life-threatening condition that affects cats across various age groups. Currently, no approved vaccines or universally accepted treatments exist (Jiao et al. 2025). Multiple risk factors that may predispose cats to FIP have been identified. Selecting appropriate sample types for diagnostic testing is crucial, with peritoneal fluid, kidney tissue, and lymph nodes offering the highest likelihood of viral detection. Interestingly, urine samples demonstrated a relatively higher rate of viral presence and load compared to other specimens. Optimizing sample selection and understanding these contributing factors can enhance early disease recognition and improve treatment success rates. These insights contribute meaningfully to the growing body of knowledge regarding FIP pathogenesis and call for continued research into both diagnostics and therapeutics (Barua et al. 2024). Although immunohistochemical analysis of tissue samples remains the diagnostic gold standard, it requires invasive sample collection, extended processing time, and expert interpretation. Therefore, serological testing is often used as an adjunct. In this study, we measured acute phase proteins, namely serum amyloid A and haptoglobin, across three different study groups. In addition, cardiac troponin I, a cardiac biomarker, was assessed in all cats.

In ruminants, abdominal ultrasonography has proven highly effective for detecting peritoneal effusions and monitoring disease progression (Mohamed 2010; Mohamed and Buczinski 2011; Tharwat 2012–2025). Similarly, abdominal ultrasonographic examination of cats with FIP in this study revealed massive peritoneal effusion, with intestines, urinary bladder, kidneys, and liver clearly visualized floating in fluid. Multiple echogenic fibrin strands created a characteristic "lace-like" appearance typical of FIP-associated exudates, underscoring ultrasonography's diagnostic value in cats. When evaluating radiographic findings, no abnormalities were found in either the healthy control group or in cats with dry FIP. In contrast, all cases of effusive FIP exhibited abdominal fluid accumulation, and approximately half also had pleural effusions. These findings support including FIP in differential diagnoses when such radiographic features coincide with relevant clinical symptoms.

Although historically considered untreatable, FIP is now manageable with antiviral agents such as GS-441524, which can induce full remission in many cases. While the traditional treatment protocol spans 84 days, emerging studies have shown that a shortened 42-day oral course at 15mg/kg can also be effective, with cats remaining in remission through day 168 and minimal side effects (Zuzzi-Krebitz et al. 2024). Despite its success in experimental settings, GS-441524 has yet to receive formal veterinary approval, leaving clinicians reliant on unofficial sources (Negash et al. 2024). Unregulated oral products may have inconsistent concentrations, improper dosing, and inadequate labeling, highlighting the need for legal access and regulation (Kent et al. 2024).

In this study, treatment with GS-441524, both oral and injectable, resulted in a high recovery rate (82.8%) with minimal relapse (12.5%). These outcomes are consistent with previous reports and support GS-441524's efficacy in both effusive and non-effusive FIP cases. Cepharanthine (CEP), when combined with GS-441524, has shown synergistic antiviral effects, representing a potential avenue for future therapeutic enhancement (Yao et al. 2025).

This study had several limitations. First, the sample size was relatively small, particularly for subgroup analyses by disease stage and treatment route. Second, postmortem examination could not be performed on deceased cats due to owner consent restrictions, limiting pathological confirmation of treatment failure. Third, while serological and RT-PCR testing were used, diagnostic sensitivity may vary depending on sample type and disease stage. Future research should focus on larger cohorts, standardized treatment regimens, and combination therapies to improve outcomes further. Additionally, development of regulated GS-441524 formulations and evaluation of novel biomarkers could enhance both diagnostic accuracy and therapeutic monitoring. Early diagnosis and prompt intervention remain critical to improving prognosis in cats with FIP.

Conclusion

FIP remains a significant diagnostic and therapeutic challenge, particularly in non-effusive forms. This study demonstrates that integrating clinical evaluation, laboratory testing, and imaging enhances diagnostic accuracy. Treatment with GS-441524, administered orally or by injection, achieved a high recovery rate (82.8%) with minimal relapse (12.5%). These results confirm GS-441524 as an effective therapeutic option for both effusive and non-effusive FIP and underscore the importance of regulated access to ensure treatment consistency. Early diagnosis and prompt antiviral intervention are critical for improving clinical outcomes in affected cats.

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Ethics Statement: All procedures were carried out in compliance with the ethical guidelines approved by the Ethics Committee for the Use and Care of Animals at Qassim University, adhering to the standards set forth in the Guide for the Care and Use of Agricultural Animals in Research and Teaching.

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